AN

ESSAY

ON THE

USEFULNES

OF

CHEMISTRY,

AND ITS

APPLICATION

TO THE

VARIOUS OCCASIONS OF LIFE.

TRANSLATED FROM THE ORIGINAL OF

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GE-

GENERAL VIEW

OF

CHEMISTRY.

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I.

UNDER the appellation of natural knowledge, taken in the moſt extenſive ſignification of the phraſe, is comprehended, whatſoever knowledge we have acquired of the nature of bodies, whether by obſervation or experiment. This branch of ſcience, in its progreſs towards perfection, may be conſidered as paſſing through three ſucceſſive ſtages; dividing itſelf, as it were, into ſo many different ſciences, which are commonly ſpoken of as diſtinct, although the limits of them are, in certain caſes, very ambiguous and difficult to aſcertain.

II.

The firſt of theſe is called NATURAL HISTORY: the buſineſs of which is, by an attentive ſcrutiny, to enquire into the ſuperficial appearances exhibited by natural bodies, eſpecially their external form; to find out in them, as often as it can be done, certain characteriſtic marks, by which any one of them may, at all times, be diſtinguiſhed from every other. The notice therefore which a natural hiſtorian, or naturaliſt as he is called, takes of a plant, for example, is of this ſort: he obſerves [by the help of characteriſtics previouſly aſcertained] what genus, ſpecies, and variety it belongs to. He obſerves, whether it is found moſt commonly growing in an open ſpot expoſed to the ſun, or in the ſhade; at what ſeaſon it flowers; whether it turns itſelf or not to the ſun; whether the flower opens itſelf or not at a certain hour of the day, &c. &c.

III.

NATURAL PHILOSOPHY [or mechanical philoſophy, as it might be called in contradiſtinction to chemiſtry] penetrates farther into the interior nature and eſſence of bodies; calls in the aſſiſtance of experiment, for the purpoſe of inveſtigating their general properties, and aſcertaining the laws, or general rules, according to which they operate. For which purpoſe the natural philoſopher, not content with obſerving the appearances they exhibit when left to themſelves, interrogates nature ſtill more cloſely; and exerciſes his invention, by putting them into a variety of new and artificial ſituations. Let us obſerve (ſtill purſuing the ſame example) in what light a man, who cultivates this branch of ſcience, conſiders a plant: he inveſtigates the quantity of its tranſpiration by a balance; he traces out its chyliferous ducts, by means of coloured liquors; he tries the influence of light upon its health and colour, by putting it into the dark, &c. &c.

IV.

In the third and laſt place comes CHEMISTRY; which, not content with inveſtigating the properties of bodies, traces out the cauſes of thoſe properties, by examining into their ingredients and compoſition. Thus, (purſuing the ſame example) upon examining a plant after the manner of a chemiſt, a man learns how much ſalt, oil, water, earth, and ſo forth, are contained in it; and further, to which of its parts the ſmell, taſte, and other properties and virtues of it, are owing.

V.

CHEMISTRY is therefore that ſcience, which examines the conſtituent parts of bodies with reference to their nature, proportions, and method of combination.

VI.

VI.

The particles which are ſeparated from one another by the chemical analyſis, or decompoſition of a body, are called its *principles*, *elements*, or *conſtituent parts*.

VII.

There are, accordingly, two methods of dividing bodies, a mechanical and a chemical; to which correſpond ſo many different ſorts of elements, or conſtituent parts.

VIII.

Mechanical elements, or parts, are each of them of the ſame nature as the whole, and are diſtinguiſhed from it no otherwiſe than by their bulk: thus, upon powdering a piece of chalk, it is reduced to a multitude of ſmaller pieces, each of which is a mechanical part, or element of the whole. Theſe are alſo called *integrant* parts.

IX.

Chemical elements is the name given to parts of different natures, which, being put together, unite into one body. Thus calcareous earth or lime, aërial acid and water, are the chemical elements of chalk.

X.

As the elements into which a body is reſolved by chemiſtry in the firſt inſtance, are ſeldom in the moſt perfect ſtate of ſimplicity, different orders of elements may accordingly be conceived.

XI.

Thoſe elements, into which, by chemiſtry, a body may be reſolved in the firſt inſtance, may be termed its proximate principles or elements: ſuch are ſulphur or brimſtone, and mercury or quickſilver, with reſpect to cinnabar.

XII.

By decompoſing again each of thoſe *proximate* principles of cinnabar, one may attain its *remote* principles: [which again may be conſidered as proximate principles with reference to the former ſet.] Thus the proximate principles of brimſtone are phlogiſton and vitriolic acid; of quickſilver, phlogiſton again, and the metallic calx of quickſilver; accordingly, vitriolic acid, phlogiſton, and quickſilver, are the *remote* principles of cinnabar.

XIII.

If the principles, into which a body has been thus reſolved, are capable of no further reſolution, they may be called primary, or ultimate principles or elements.

XIV.

The diviſion or reſolution of a body into its principles or elements, is termed chemical analyſis; as the putting together of bodies of the ſame ſorts as thoſe principles, ſo as to make up a body of the ſame ſort as that ſo analyſed, is termed chemical ſyntheſis.

XV.

It is then only we can be ſure of our knowing what the real conſtituent parts, or elements of a body are, when the analyſis and ſyntheſis of it tally with each other.

XVI.

The nature of a body depends, not only on the *nature* of its elements, but likewiſe on the *proportion* in which they are found in it, and the manner in which they are connected. Common field marle contains the ſame elements as the topaz; at the ſame time the properties of theſe two bodies are altogether different,

XVII.

The coheſion that takes place between the elements of a body, depends upon the force with which they attract one another, and is proportioned to that force.

XVIII.

All bodies in nature have an attraction for each other.

XIX.

In the heavenly bodies this attraction exerts itſelf according to one ſimple law; but among the ſmall bodies which compoſe our globe, this force is different, according to the different nature of thoſe bodies.

XX.

If three different particles, A, B, and C, meet together, and two of them unite in ſuch a manner as to exclude the third, this is called ſimple elective attraction.

XXI.

If A, being united with C; afterwards, upon B's being applied to them, unites with B, and lets go C; A is ſaid to poſſeſs a greater attraction for B than for C: thus, if you pour vitriolic acid upon common ſalt, it is found, that the mineral alkali of the ſalt has a greater attraction for the vitriolic acid, than for the marine acid, with which it was before combined, as it leaves the latter, and unites with the former. The vitriolic acid is alſo ſaid to have a ſtronger attraction for the mineral alkali, than the marine acid has; and, accordingly, the former acid is ſaid to expel the latter acid from its baſis.

XXII.

The relations thus ſubſiſting among a number of ſubſtances, are, for the ſake of conciſeneſs and convenience of inſpection, repreſented by placing the names of thoſe ſubſtances (expreſſed by peculiar characters) one above another, in columns; and a number of ſuch columns put together, compoſe what are called tables of attraction or affinity.

XXIII.

The attractive forces which any greater number of bodies than three, upon meeting, exert one upon another, is called compound attraction; and, in particular, when four bodies operate upon one another in this manner, at the ſame time, double attraction.

XXIV.

When two ſubſtances are united together, no third ſubſtance added to them will effect a ſeparation between them, unleſs ſuch third ſubſtance has a ſtronger attraction for one of them, than the other has. When pure calcareous earth is diſſolved in nitrous acid, cauſtic volatile alkali alone will not ſeparate them, becauſe the attraction of the alkali for the acid, is not ſo ſtrong as that of the calcareous earth is.

XXV.

But what cannot be done by a third ſubſtance alone, is often effected by that in conjunction with a fourth: thus, to the pure *calcareous earth*, as in the foregoing example, let aërial acid be added, and the ſeparation is effected: the aërial acid acting upon the calcareous earth on the one hand, at the ſame time that the alkali acts upon the nitrous acid on the other, diminiſhes the coheſion of the earth with the nitrous acid to ſuch a degree, that the volatile alkali is now able to unite itſelf to the latter acid, and expel the earth.

XXVI.

To the exertion of theſe two ſorts of attractions, ſimple as well as double, fluidity is neceſſary on the part of ſome one, at leaſt, of the ſubſtances concerned. But this fluidity is ſuſceptible of two different forms, according to which attractions are ſaid to be exerted in ſo many different ways, which are called the humid way and the dry.

XXVII.

It is called the humid way, when one of the ſubſtances, at leaſt, is fluid in the heat of the atmoſphere, or at leaſt in a heat not much greater than that of the atmoſphere; and this is the caſe in the ſeveral examples above-mentioned.

XXVIII.

It is called the dry way, when, in order to produce the neceſſary degree of fluidity, ſubſtances (while as yet in a dry ſtate) are expoſed to a conſiderable degree of additional heat: for inſtance, by the application of burning fuel. Thus, if cinnabar be mixed with iron filings, and a certain degree of heat be applied, the quickſilver of the cinnabar will riſe up, leaving the brimſtone (which is the other element of the cinnabar) combined with the iron; the brimſtone attracting the iron ſtronger than it does the quickſilver. This is a caſe of ſimple attraction. Again, if *hydrargyrum vitriolatum* [quickſilver united with the acid of vitriol] be mixed with *alkali minerale ſalitum*, [common ſalt] and a certain degree of heat is applied, a new combination takes place among the ſubſtances concerned, in virtue of a double elective attraction: the marine acid of the common ſalt unites itſelf with the quickſilver of the mercurial ſalt, forming a new mercurial ſalt, called corroſive ſublimate [*hydrargyrum ſalitum fortius*]; while the mineral alkali of the common ſalt combines with the vitriolic acid of the firſt mercurial ſalt, forming what is called Glauber's ſalt.

XXIX.

The whole ſyſtem of theſe ſet of *elective* attractions, double as well as ſingle, may be repreſented in the moſt commodious manner, ſo as to be comprehended at a ſingle glance, by the tables above-mentioned [ſ. 22]; (*a*) by means of which the whole theory of attractions, which forms ſo important a branch of chemiſtry, is placed in a very intelligible point of view.

XXX.

Since then all chemical operations are reducible to analyſis or ſyntheſis, that is, to diſcombination, as it may be called, and recombination of ſubſtances; and as theſe operations depend upon the laws of this ſpecies of attraction, it appears that the knowledge of theſe laws muſt be, as it were, the key to the whole ſcience.

XXXI.

Chemiſtry, in ſo far as it applies itſelf to throw a light upon the general courſe of nature, and the cauſes of the ſeveral phenomena

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(*a*) A new table of affinities, or elective attractions, publiſhed by Mr. Bergman, in the Acta Upſalenſia, Vol. II. ſince the publication of the original of this eſſay, is annexed to this tranſlation.

nomena exhibited by bodies, may be termed [*chemia pura*] pure, general, or philoſophical chemiſtry.

XXXII.

But when it enters, more or leſs, into details, and applies itſelf to uſe, by teaching us, partly, how the ſeveral ſorts of bodies, according to their reſpective natures, may be employed, when at hand, in the moſt advantageous manner, to the ſeveral purpoſes of life; partly how they may be preſerved and ameliorated, or even, if not at hand, how they may be prepared; it may be termed [*chemia applicata*] mixt, particular, or popular chemiſtry, after the ſame manner that mathematics is denominated in the like caſes.

XXXIII.

Chemiſtry, like mathematics, may alſo be diſtinguiſhed into [*chemia vulgaris*] vulgar or elementary chemiſtry, which concerns itſelf only with the groſſer and more palpable elements of bodies; and [*chemia ſublimior*] tranſcendental chemiſtry, which, not neglecting the groſſer and more palpable elements, finds means, by particular contrivances of its own, to collect and examine thoſe elements of finer texture, which otherwiſe, in conſequence of a degree of ſubtlety which renders them imperceptible to our ſenſes, would fly off and eſcape our notice. Theſe finer elements may be conſidered, in ſome reſpects, as correſponding to the fluxions and infiniteſimals of the ſublimer or tranſcendental geometry.

XXXIV.

The tranſcendental chemiſtry requires particular talents, as well for the deviſing as for the executing of ſuch experiments as are beſt calculated to bring forth the truth with certainty. Since the rapid ſtrides which chemiſtry has made within theſe laſt twelve or fifteen years, it is become abundantly evident, how imperfect the knowledge of thoſe perſons muſt be, who chuſe to confine themſelves to vulgar chemiſtry. But it is not to be wondered at, if men, who poſſeſs neither the talents nor patience neceſſary to ſuch nice enquiries, ſhould ſeek to palliate their own deficiency, by ſlighting them under the name of ſubtleties. Mean time, that a ſubſtance which oftentimes conſtitutes a great part, even as far as half the weight and, ſometimes more, of the body in which it is found, is an object not worth attending to, and which as ſuch may be thrown away, or ſuffered to eſcape unheeded, is a proportion which cannot but appear to be rather an extraordinary one. In fact, a man who conſiders nature with ever ſo little attention, cannot ſurely help being aware, that every thing that we ſee happens in conformity to certain laws; and that the ſmalleſt circumſtances have their cauſes, as well as the greateſt. In the ſyſtem of nature every phenomenon is connected with every other; inſomuch that we may be warranted in ſaying, that in this branch of ſcience, either there are no ſuch things as ſubtleties, or that here even ſubtleties themſelves are not to be contemned.

XXXV.

As we are continually employing the different ſubſtances in nature in ſubſervience to our different neceſſities, there needs not much profound ſtudy to apprehend, in a general way, the uſe of that ſcience, the buſineſs of which it is to inveſtigate thoſe circumſtances in the compoſition of bodies, on which their various differences are grounded. However, in order to give a more detailed and particular view of its utility, it may be proper to diſtinguiſh popular chemiſtry into various ſubordinate branches, and to beſtow on each of them a ſeparate conſideration.

XXXVI.

There are but three reſpects, in which the ſeveral ſorts of bodies which we are converſant with, can be made ſubſervient to our uſe; *viz.* in reſpect to our health, in reſpect to our maintenance, and in reſpect to the pleaſures and conveniencies of life.

XXXVII.

Accordingly, popular chemiſtry may be divided, in the firſt inſtance, into three branches; the medical, the œconomical, and the technical.

MEDICAL CHEMISTRY.

XXXVIII.

The objects of medical chemiſtry are ſuch ſubſtances as are capable of being made conducive to our health. But, as the ways in which they may be made ſubſervient to that purpoſe are different, this branch of chemiſtry is accordingly ſuſceptible of a number of ſubdiviſions; all which may here be mentioned, though the nature of this deſign admits not of their being conſidered otherwiſe than in a very general point of view.

XXXIX.

Medical chemiſtry has naturally two objects in view: to wit, firſt, the knowledge of the chemical properties of the living body, to the health of which it propoſes to be ſubſervient; and, ſecondly, of the ſeveral other ſubſtances which are of a nature to contribute, more or leſs, to that deſign.

XL.

The firſt of theſe diviſions conſtitute what may be termed phyſiological chemiſtry. The buſineſs of this branch is, in the firſt place, to lay open the texture and compoſition of the ſeveral ſolid as well as fluid ſubſtances of which the body, as well in a healthy as in a morbid ſtate, is compoſed: in the next place to explain the ſeveral chemical proceſſes, which are going on in every part of the body: ſuch as digeſtion, preparation of chyle, of blood, of gall, of the pancreatic juice, &c.

XLI.

This branch is as yet but in its infancy; although, on the one hand, the cultivation of it cannot but be of the greateſt advantage to medicine; and, on the other hand, the neglect of it has given admiſſion to a great part of that prodigious variety of abſurd poſitions, with which that ſcience has hitherto been overwhelmed. One example will be ſufficient: entire works have been written on the production of the ſtone in the bladder from calcareous earth, although the moſt exact analyſis cannot diſcover in it, upon an average, above one part in a hundred of this earth. One may judge by this, how well grounded many of the expedients have been, which we have ſeen propoſed for the diſſolving of the ſtone.

XLII.

The other principal branch reſpects the knowledge of the chemical properties of the ſeveral ſubſtances, which are found to be beneficial or noxious to health. This may be comprehended under the name of *pharmaceutical chemiſtry*.

XLIII.

This branch comprehends again other branches of ſcience, which it may be of uſe to diſtinguiſh from one another.

XLIV.

To this head belongs, in the firſt place, the knowledge of the conſtituent parts or elementary ingredients of the ſeveral bodies which are made uſe of, whether for the purpoſe of medicine or of nouriſhment. The ſubſtances we are taking in continually in the way of diet, produce not ſuch quick and remarkable changes in the body as medicines do: however, at the long run, the influence of the former on our health is too evident to admit of their being excluded from conſideration in the preſent inſtance.

XLV.

It is further neceſſary to underſtand how to ſeparate the uſeful parts of thoſe ſubſtances, from ſuch uſeleſs or pernicious ones as they may happen to be encompaſſed with; alſo how the uſeful parts, ſo ſeparated, may be prepared, as well each of them by itſelf, as any number of them together; in ſuch manner, as that they may poſſeſs the leaſt unpalatable, and the moſt commodious form. This branch commonly goes by the name of pharmacy: it ſuppoſes great extent of knowledge, if regarded, as it ought to be, upon the footing of a ſcience.

XLVI.

XLVI.

As to water and air, although what concerns the properties of theſe two ſubſtances might be properly enough ranked under a former diviſion [ſ. 44]; yet, as they are of ſuch neceſſary and extenſive uſe, they may ſeem, on that account, to claim each of them a ſeparate conſideration.

XLVII.

The buſineſs of the *hydrological* branch of chemiſtry will accordingly be, to inveſtigate the nature of the ſeveral ſorts of waters, with regard to the ſeveral heterogeneous ſubſtances which they are apt to contain, and to which all the differences which are obſervable in them are owing.

XLVIII.

This branch of the ſcience affords us then an effectual ſet of expedients, for imitating by art all ſuch naturally impregnated waters as are valuable enough to be worth the trouble : which may be the caſe, either on account of their not being to be had at all in the places where they are wanted, or not at ſo low a price as they may be made for.

XLIX.

Water has more or leſs to do with almoſt every thing we eat; and forms the greateſt part of every thing we drink: the different impregnations which this ſubſtance is apt to receive, cannot therefore but be of ſome conſequence, more or leſs, upon every occaſion.

L.

The *aërological* branch, the buſineſs of which is to inveſtigate the nature and properties of the different kinds of air, is not leſs intereſting than that laſt mentioned. On every ſide we are ſurrounded with this element, in which we live as fiſhes do in water. The different modifications of which it is ſuſceptible, not only have a very conſiderable influence upon perſpiration, that proceſs ſo intimately connected with our health, but are alſo indiſpenſably neceſſary to the continued motion of the lungs, thoſe bellows by which the flame of life is kept alight. It is not enough that they are kept diſtended by any kind of elaſtic fluid. A certain quantity of a particular kind of elaſtic fluid is neceſſary for this purpoſe. Of this quantity, that part which is perfectly pure, and which of itſelf is the only part that is fit for reſpiration, makes always but a ſmall proportion, and ſeldom more than a fourth part, of the whole atmoſpheric maſs; the reſt is altogether unfit, and, of itſelf, would extinguiſh life in a few moments.

LI.

The ſtate of the air is not only very different in low and elevated ſituations, in open places, and cloſe rooms; but even in the ſame room, it is ſcarce every where exactly alike: it is therefore of no ſmall importance to be informed of theſe inequalities, which, as far as concerns fitneſs for reſpiration, may be pretty exactly meaſured by the new-invented inſtrument, called the *Eudiometer*.

LII.

Thus much is enough to ſhow, that, without the help of chemiſtry, the art of medicine cannot but fall very far ſhort of its perfection.

ŒCONOMICAL CHEMISTRY.

LIII.

In rural œconomy there are ſeveral proceſſes, which, in order to ſucceed under all circumſtances, ſtand in need of receiving more or leſs light from chemiſtry: ſome of the principal of theſe we ſhall here enumerate.

LIV.

In a general view, this branch of buſineſs may be ſaid to have two objects: in the firſt place, to produce certain ſubſtances in the ſtate of raw materials; in the next place, ſo to deal with them, as to turn them to the beſt advantage.

LV.

Raw materials, from the vegetable kingdom, which are the objects of rural œconomy, are all ſorts of grains, roots, and fruits, ſtalks and leaves of herbaceous plants; ſuch as hay, flax, hemp, &c. In milder climates grapes, olives, &c.

LVI.

All theſe ſeveral articles, in order to be produced in perfection, require each of them its proper and peculiar management: a proper kind of earth muſt be procured for them, or the earth that is at hand muſt be rendered ſo by art, if the huſbandman would be rewarded for his labour.

LVII.

Beſides the earth in which they grow, vegetables muſt be ſupplied with matters proper for their nouriſhment; and in particular with ſuch as are calculated to conſtitute their ſolid parts. But theſe, in order to be carried up through the roots, require the aſſiſtance of water, being the vehicle which is the beſt adapted to this purpoſe.

LVIII.

A good earth muſt therefore contain, in the firſt place, a ſufficient quantity of nutritive materials; and, beſides, a ſufficient quantity of water, to ſerve as well in the way of nouriſhment as in the capacity of a vehicle, for the nouriſhment that may be afforded by other ſubſtances.

LIX.

The mineral earths which are moſt commonly found in the common ſoil are clay, ſand, and calcareous earth; with which are intermixed a greater or leſs quantity of vegetable ſubſtances, which, as they putrify, loſe their organical texture.

LX.

Of theſe three earths there is not any one which, by itſelf, is fit for the ſupport of vegetables. In a good ſoil they are therefore always found mixed, at leaſt two of them together.

LXI.

Clay retains water the longeſt; after clay, calcareous earth; ſand dries the quickeſt. Hence it follows, that from the different proportions in which they may be mixed, reſult ſo many differences with regard to their capacity for retaining water.

On this occaſion the inferior ſtrata require to be conſidered as well as that which forms the ſurface of the ground.

LXII.

The beſt earth being barren, and, as it were, lifeleſs, without water, it is obvious, that that mixture is the beſt, which is beſt adapted to the mean ſtate of the weather, with reſpect to drought and moiſture: unuſual accidents are not to be prevented by human foreſight.

LXIII.

But the influence of *ſituation* is ſuch, that the ſame mixture in different places has different effects. The buſineſs is therefore to find out that mixture, which is beſt ſuited to the ſituation of the ſpot.

LXIV.

If the farmer then knows how to diſtinguiſh the different kinds of earth in his grounds, and to judge of the proportions in which they are mixed, in the ſame manner nearly as a miner judges of the contents of his mines; he may, by due obſervation and reflection, be able, in the courſe of a few years, to determine what mixture is beſt ſuited to his ſituation.

LXV.

To grow corn in a field, and to produce it in the greateſt poſſible quantity, are two very different things; the former may be compaſſed without any very great ſtock of knowledge; but by no means the latter, unleſs perhaps by great chance.

LXVI.

The uſes which chemiſtry may be of in agriculture are very conſiderable; but the limits of this deſign will not allow of our doing any thing more, than juſt to mention the principal of them in a few words. To chemiſtry it belongs to diſtinguiſh the different kinds of earth, according to their natures and proportions; to determine which of them are the fitteſt for different purpoſes; to aſcertain the different qualities of the various ſorts of manures; and to point out proper methods of applying them; to produce them in ſuch quantities as may be required; to aſcertain the beſt method of improving a poor ſoil; to effect, by a mixture of earths, what is not to be done by manure alone.

LXVII.

Agriculture, that moſt honourable and ancient of profeſſions, has ſcarcely ſince the time of the Romans received any eſſential improvements. The reaſon is, not that it is already at its perfection, but that a ſufficient ſtock of natural knowledge has never been hitherto applied to it. The great object has been to make fields look like the flower-beds in a garden; but then the field ought to be as eaſy to water as a garden, or a man will find the impropriety of this method to his coſt.

LXVIII.

When the productions of agriculture are at length obtained, the aid of chemiſtry is ſtill as much wanted as ever, for the purpoſe of preſerving and improving them.

LXIX.

Brewing, baking, making brandy, cyder, wine, and vinegar, are all of them ſo many chemical proceſſes; which, for want of the requiſite ſtock of knowledge, in many caſes, either fail altogether, or are carried on with little profit. To this head likewiſe belongs the preparation and preſervation of yeaſt, or leaven.

LXX.

Other uſeful branches of rural œconomy, are thoſe that concern the preparation and production of ſyrups from the different ſubſtances which afford a ſaccharine matter; the preparation of ſtarch: alſo that of flour and gruel from potatoes, &c.

LXXI.

To prepare flax and hemp in ſuch a manner as to yield the fineſt, ſtrongeſt, and ſofteſt threads; to bleach linen, ſo as to give it the pureſt white, without loſing its ſtrength; to preſerve wood from putrefaction; to enable wainſcot and paper-hangings to reſiſt the fire &c; are ſo many problems, which can look only to chemiſtry for their ſolution.

LXXII.

From the animal kingdom the farmer collects raw materials, ſuch as eggs, meat, tallow, wool, hair, feathers, hides, milk, honey, wax, &c. many of which by chemical art, if neceſſary, may be preſerved uncorrupted for a conſiderable length of time, or may even, in ſome inſtances, be reſtored in good meaſure to a ſound ſtate, after corruption has begun to take place.

LXXIII.

By the improvement of the raw materials, are obtained butter, cheeſe, ſugar, yarn, flax, thread, packthread, cordage, and many other articles, by proceſſes which may be carried on with much greater facility and ſucceſs, if the chemical nature and properties of the ſeveral materials be underſtood.

LXXIV.

Further inſtances, in which the farmer may occaſionally find a conſiderable advantage by underſtanding chemiſtry, will appear under the head next enſuing.

LXXV.

A multitude of proceſſes, which ſometimes are carried on in the ſmall way in families, at other times, being carried on in the large way, conſtitute the buſineſs of ſo many ſeparate manufactories, or profeſſions; and may, on this account, be referred to the head of *technical chemiſtry*.

TECHNICAL CHEMISTRY.

LXXVI.

The application of chemiſtry to arts and manufactures is of very great extent: ſome of them are nothing but a chain of chemical proceſſes from beginning to end; others belong, in certain ſtages of their progreſs, principally to mechanics, but at the ſame time require the aſſiſtance of chemiſtry at certain other periods.

LXXVII.

LXXVII.

This being premiſed, technical chemiſtry may, in conformity to the chemical arrangement of bodies, be divided into five branches, viz. firſt, *halurgic chemiſtry*, or that which relates to ſalts; ſecondly, *geurgic*, or that which relates to earths; thirdly, *theiurgic*, or that which relates to ſulphureous bodies; fourthly, *metallurgic*, or that which relates to metals; fifthly, *opificiary* (*b*), or that which relates to the ſeveral ſorts of arts and manufactures.

LXXVIII.

Arts and manufactures were, for the moſt part, in their origin the work of chance; and ſince then receiving improvement by continual and ſucceſſive trials, have been brought to the degree of perfection at which we ſee them now; commonly, without being obliged to ſcience

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(*b*) See 144.

for their advancement. But this is no proof, but that the ſucceſs of them is founded on certain chemical truths or axioms, on certain general facts, which it comes under the province of chemiſtry to teach and to explain; and on account of which, it conſequently cannot but receive conſiderable light from chemiſtry: ſome it has received already, and doubtleſs it would have received much more, had it not been for that veil of myſtery, with which private intereſt naturally ſeeks to cover thoſe lucrative employments.

LXXIX.

It is the buſineſs of the *halurgic branch* of chemiſtry, to teach the art of preparing and purifying the ſeveral ſorts of ſalts. [See ſections 162 to 191.]

LXXX.

To this head therefore belongs the preparation of the mineral acids, of which number thoſe for which there is the greateſt demand in trade, are; firſt, that which is made from vitriol or ſulphur, the vitriolic; ſecondly, that which is made from ſalt-petre, or, as it is otherwiſe called, nitre, the nitrous; thirdly, that which is made from common ſalt, the marine, or muriatic. Of vegetable acids, that of vinegar is the only one which is prepared in the large way; the preparation of the others being confined to chemical laboratories, and apothecaries ſhops.

LXXXI.

The fixed alkalis, ſuch as that of potaſh and that of ſoda, are articles of trade. Volatile alkali is moſtly prepared in apothecaries ſhops.

LXXXII.

Of the neutral ſalts, including as well thoſe which are perfectly ſaturated [ſee 183] ſuch as Glauber's ſalt, ſalt-petre, common ſalt, and ſal ammoniac [ſee 184] as thoſe which are ſuperſaturated, ſuch as tartar and borax [ſee 185] thoſe here mentioned are prepared and purified in the large way; the others for the moſt part only in apothecaries ſhops.

LXXXIII.

Sugar may be conſidered as a kind of vegetable eſſential ſalt, of which, in our times, a conſiderable quantity is conſumed. The art of refining it is ſtill capable of receiving many lights from chemiſtry.

LXXXIV.

Of the earthy compound ſalts [ſee 188], which occur in trade, nature herſelf prepares gypſum [ſee 200]; as alſo, in ſome places, the ſal amarum [ſee 202]; but alum is ſolely produced by art [ſee 204].

LXXXV.

The metallic compound ſalts which occur in trade, are all of them prepared by art. The principal of them are, firſt, blue vitriol, or vitriol of copper; ſecondly, green vitriol, or vitriol of iron; thirdly, white vitriol, or vitriol of zinc; fourthly, corroſive ſublimate, or mercury combined with marine acid; fifthly, ſaccharum ſaturni, or vinegar combined with lead; and ſixthly, verdigreaſe, or vinegar with copper.

LXXXVI.

In the preparation of many of theſe ſalts, many important improvements have been made in our own times by the means of chemiſtry; and, in particular, we are now able to obtain the mineral acids with much leſs trouble, as well as expence, than formerly; and there is the greateſt reaſon to hope, that more and more improvements reſpecting the preparation of thoſe ſubſtances will be diſcovered.

LXXXVII.

The geurgic branch of chemiſtry comprehends all the preparations, of which any kind of earth conſtitutes the principal ingredient. The calcareous, argillacious, and ſilicious earths are employed, not only in agriculture, but to ſeveral other purpoſes.

LXXXVIII.

Calcareous ſtones are burnt; whereupon, if water is poured upon them, they fall into a powder, which is the principal ingredient in the mortar uſed for walls. If it be mixed with a little Manganeſe [ſee 259] it forms black chalk, which is found particularly uſeful in ſuch maſon's work as is done under water.

LXXXIX.

It is from chemiſtry that we learn the nature of the change which chalk undergoes upon being burnt: viz. that a quantity of aërial Acid and water, amounting together to a little more than half its weight, eſcapes from it, and that a certain quantity of the matter of heat is ſet at liberty [ſee 297]. Thus informed, we have not only obtained juſt notions reſpecting the properties of this earth, but we are alſo enabled to lay down rules, with more exactneſs than before, for burning and extinguiſhing it, for preſerving its properties unimpaired, and for employing it to the beſt advantage.

XC.

Argillacious earth, or Clay, when prepared with a certain quantity of water, poſſeſſes a degree of tenacity, which renders it fit to be moulded into various forms. Upon being baked, it contracts conſiderably, and is apt to crack, if it is not mixed with a ſufficient quantity of ſand. Not only this mixture, but clay by itſelf, acquires a very conſiderable degree of hardneſs in the fire. In virtue of theſe properties, a variety of uſeful articles have been made out of it, differing from each other in reſpect of the goodneſs of the materials, the nicety of the workmanſhip, and the beauty and convenience of the form.

XCI.

Every one knows the uſe that bricks and tiles are of in building; the former to compoſe the ſubſtance of the walls, the latter to form the covering of the roof.

XCII.

In regard to bricks, which are to be bedded in good mortar and covered with it all round, much nicety in the choice of the clay is not required; it is enough if it be but equally worked throughout and well burnt; but for thoſe which are expoſed to all the viciſſitudes of the weather, a greater degree of nicety is required.

XCIII.

The purer the clay is, the better it is for bricks and tiles; for ſince the purer it is, the more it contracts, it is therefore the leſs diſpoſed to receive water; which, in freezing, burſts the ſtrata of particles which are contiguous to it, and, little by little, crumbles down the whole ſubſtance of the brick.

XCIV.

If there happens to be a little lime in the clay, tiles that are made of it, if burnt in the common way, are incapable of laſting long in the open air without a cover; for the calcareous particles, attracting moiſture, are waſhed out, leaving holes; which, filling with water, form, as it were, ſo many little mines; which, as ſoon as a froſt comes, explode and burſt through the ſubſtance in which they are incloſed. This imperfection is obviated, by giving a vitreous coating to the ſurface; which is done by the force of fire, either alone, or aſſiſted by a little common ſalt, which is ſtrewed upon them in the kiln. This glazing pretty effectually anſwers the deſired purpoſe.

XCV.

For theſe and a number of other circumſtances that occur in the arts of brick-making and tile-making, ſuch effectual proviſion may be made by the help of chemiſtry, that thereby there is ſcarce any ſort of clay but what may be made to ſerve.

XCVI.

Of common clay are likewiſe made a variety of the ordinary ſorts of potters ware, as well glazed as unglazed.

XCVII.

Potters ware, when covered over with a kind of enamelled glazing, forms that particular kind which is called Delft ware.

XCVIII.

A kind of reddiſh brown clay, containing iron, is likewiſe made into a variety of utenſils, for the moſt part unglazed; in which ſtate the earth is called by ſome *terra ſigillata.*

XCIX.

Clays, ſuch of them as are qualified to reſiſt the fire, are made into crucibles, muffles, retorts, and a variety of other veſſels uſed in chemiſtry.

C.

Veſſels made of the finer and apyrous, and perfectly opake ſorts of clays, and which uſually are glazed, are called *ſtone ware.*

CI.

A white, ſemi-tranſparent apyrous earth, which ſtrikes fire with ſteel, forms, when incruſted with a glazing of chryſtalline earth, a kind of ware, which is called *porcelain*, or *true china.* To the compoſition of this ſubſtance there needs an apyrous clay, which by burning becomes white, and another earth, called in China petuntſe, tüntſe, which ſerves to bring clay to a half-melted ſtate, neceſſary to its ſemi-tranſparency.

CII.

Along with the pureſt clay there is always mixt a conſiderable quantity of ſiliceous earth; the more there is of this, the leſs it is neceſſary to add, in order to prevent the clay from cracking.

CIII.

Siliceous earth, brought into fuſion by an alkali, forms the moſt common ſorts of *glaſs*.

CIV.

Glaſs may be made to receive various colours, by means of metallic calces mixed up with the other compoſition before it is reduced to fuſion: glaſs thus coloured is called *Fluor*.

CV.

When the colouring additament is of ſuch a nature as to deprive the glaſs of its tranſparency, the maſs is called *enamel.*

CVI.

A maſs of this ſort, when white and ſemi-tranſparent, has been called *falſe porcelain.* Alſo the common bottle glaſs may be converted into a ſubſtance, which, in its appearance as well as its other properties, approaches very near to real porcelain: this is called, after its inventor, *Reaumur's porcelain.*

CVII.

All theſe different ſorts of earthen ware, in order to be brought to perfection, require a conſiderable degree of knowledge as well as practice, as well with regard to the nature of the materials, as with regard to the method of mixing and working them, the degree of fire proper to be given them, &c. &c.

CVIII.

To the *Theiurgic branch of chemiſtry* belong ſuch preparations as contain a conſiderable quantity of phlogiſton. Of theſe, according to the different nature of the other ingredients, there are various ſorts.

CIX.

Sulphur or brimſtone [ſee 212] is applied to a variety of purpoſes: it is obtained by diſtillation from ſulphureous pyrites.

CX.

The *phoſphorus of urine* [ſee 215], which is likewiſe a kind of ſulphur, has been applied hitherto to no other purpoſe than that of chemical experiment. It is ſtill very dear; but, with proper materials and proper management, it may be made at very little expence.

CXI.

From the ſeeds of ſeveral plants are obtained, by preſſure, the ſorts of oils that are called the *fat* [*unguinous*], or expreſſed vegetable *Oils* [ſee 229]. Some of them become dry by time, others not, and they are accordingly applicable to different purpoſes. There are likewiſe certain proceſſes, by which they may be rendered fitter for their reſpective uſes.

CXII.

From the animal kingdom expreſſed oils are obtained by melting [ſee 226]. Spermaceti is a fluid ſubſtance of this kind, which uſed to be obtained only from the brain of certain ſorts of whales; but ſince a method has been found out of obtaining it from the common fluid oil extracted from thoſe fiſh, the price of it is conſiderably fallen. Spermaceti, when purified, is the beſt ſubſtance to make candles of any that is yet known.

CXIII.

The expreſſed oils, as well animal as vegetable, combined with alkaline ſalts, form ſeveral ſorts of *ſoaps*, which are of different fineneſs and goodneſs, according to the nature of the ingredients.

CXIV.

The *eſſential oils* [ſee 227] are obtained for the moſt part only by diſtillation; though ſome of them, ſuch as the oils of oranges and lemons, are obtained by ſimple preſſure. The principal of thoſe that are prepared in the large way, are obtained from the Indian ſpices: they are all expoſed to a number of adulterations. Chemiſtry, however, is able not only to diſcover the fraud, but frequently alſo to determine the quantity and quality of the ſpurious matter.

CXV.

Sweet-ſcented waters are prepared from eſſential oils diſſolved in ſpirits of wine.

CXVI.

Brandy, *ſpirits of wine* [ſee 233], and *alkohol* [ſee 234], are often prepared in the large way; but the ſeveral kinds of *Ether* [ſee 231, 232], are hardly made any where but in chemical laboratories, and apothecaries ſhops.

CXVII.

The preparation of *gunpowder* [ſee 236] is a ſubject the more particularly intereſting, inaſmuch as the art of war, as practiſed in modern times, in a great meaſure depends upon it. The three great objects here are to make it of the ſtrongeſt quality, at the cheapeſt rate, and in the ſafeſt manner.

CXVIII.

To this head likewiſe belong the ſeveral contrivances for making the different ſorts of combuſtibles that are made uſe of, either in war, or for paſtime. This art is commonly called *Pyrotechny*, or the art of fire-working. The principal deſideratum here, is the art of making a pure green fire, for which, however, chemiſtry affords ſeveral expedients.

CXIX.

As the colours of bodies depend on the reflection, tranſmiſſion, and refraction of the rays of light; and as the changes, thus undergone by the light, ſeem to depend upon the phlogiſton contained in the ſubſtances concerned; it follows, that the ſeveral contrivances for fixing colours on different bodies, naturally belong to the Theiurgic branch of chemiſtry.

CXX.

Dying is the name given to the art, which, by impregnating a ſubſtance with a liquor prepared for the purpoſe, beſtows on it the colour which is deſired. The preparation, which the ſubſtance to be dyed is made to undergo, by means of certain ſalts, in order to make it take the colour the better, is called ſteeping.

CXXI.

This art is diſtinguiſhed into ſeveral branches, according to the nature of the ſubſtances to be dyed; the principal of which are wool, ſilk, cotton, and linen. Theſe ſubſtances differ very much with regard to the degree of facility with which they receive colours: wool, the eaſieſt; after wool, ſilk; cotton and linen receive and retain them with the greateſt difficulty.

CXXII.

Linen, in order to be rendered ſuſceptible of certain colours, muſt receive an impregnation from ſome animal ſubſtance. As, by this means, it is brought nearer to the nature of wool, or other ſuch animal productions, the proceſs may be called *animalization.*

CXXIII.

The goodneſs of a colour depends not merely on its beauty and brilliancy, but alſo on its capacity of ſuſtaining the influence of the ſun and weather unaltered; to which may be added, in cloaths of a vegetable origin, their capacity of ſuſtaining the action of ſoap in waſhing without change.

CXXIV.

By means of chemiſtry many diſcoveries have of late been made, as well in reſpect to novelty of colour, as conſtancy of duration, and certainty of effect. A few examples will ſuffice: ſilk may now be made to receive the deepeſt ſcarlet; cotton the red Turkiſh colour, in different ways; linen a true black. In ſeveral caſes, Pruſſian blue may now be ſubſtituted in the room of indigo; and even this dear colour may now, in ſeveral inſtances, be employed to better advantage than before.

CXXV.

Painting is an operation altogether different from dying: in the former caſe, a ſubſtance of ſome thickneſs is ſuperinduced upon that which is to be coloured; in the latter, by means of a kind of attraction, the ſubſtance in queſtion is covered with a merely ſuperficial ſtratum of ſuch particles as reflect the rays, which exhibit the colour we deſire. That proceſs, by which a thin colouring is given to wood, horn, leather, bones, &c. may be conceived as ſomething between the former two. In this latter caſe, ſometimes the ſubſtance is only waſhed over with the colouring tincture, ſometimes it is ſet to ſteep in it.

CXXVI.

The method of painting, in which the colours are employed dry, is called *Painting in crayons:* and this kind of work has alſo received improvements of late in point of durability. In the more common kinds of painting, the colouring materials are ground and mixed with oil, water, or ſpirit of wine, according to the purpoſe which is in view. In all theſe caſes, it is only the production and attachment of the colouring matter that comes under the department of chemiſtry. The deſign and delineation of the figures belongs to a particular art, which ought not to be confounded with that which reſpects only the nature and preparation of the colours,

CXXVII.

To this head alſo belong the different coloured *inks*; of which thoſe kinds are called ſympathetic, which remain inviſible, until the colour is brought forth by heat, or by ſome other means. By means of theſe inks many pretty effects may be produced in drawings.

CXXVIII.

The black, and other colours which are uſed by printers and engravers, and are ſtamped on by plates, blocks, or types, require great nicety in the compoſition, in order to their being made to anſwer perfectly.

CXXIX.

To take away other colours is likewiſe an object in ſome caſes, in order to obtain a perfect white: for this purpoſe, according to circumſtances, different expedients are employed. Bleaching, for example, upon linen; and the fumes of ſulphur upon ſilk and wool.

CXXX.

There is likewiſe a method of applying colours by fuſion in the dry way. Examples of this are the different colours given to ſealing-wax: formerly the blue was very much eſteemed; but it is generally believed, that the art of making it is loſt. The coloured glaſſes are made by melting common glaſs with the metallic calces; and they are at pleaſure rendered tranſparent or opake. By theſe means china may be made to receive colours, which afterwards muſt be burnt in.

CXXXI.

In this way alſo it is, in many caſes, an object to diſcharge colours out of fuſible ſubſtances, whether tranſparent or opake. To obtain glaſs colourleſs, beſides the ordinary materials, it is neceſſary ſometimes to employ nitre, and frequently alſo manganeſe:

ganeſe: both of which ſtrongly attract phlogiſton. When nitre is employed, the acid, combining with the phlogiſton which gave colour to the maſs, flies off with it. The manganeſe, on the contrary, combining with a certain proportion of phlogiſton, detains it, forming with it a compound which is colourleſs; though in any other proportions its particular colour always appears.

CXXXII.

To be able to preſerve inflammable ſubſtances from conflagration, is doubtleſs an object of a moſt capital nature, on which, of late days, much ſtudy has been employed; and, as is ſhewn by the experiments which have been made, not without conſiderable ſucceſs. The wood-work of houſes may be made to reſiſt fire a long while, by being covered over with clay. Wood and paper, well impregnated with a lixivium of pearl-aſhes, will not catch fire. Alum and common ſea-ſalt, &c.

will produce the ſame effect. Another property of a ſolution of ſea-ſalt is, that it does not eaſily freeze; on which account it may be employed with particular advantage in quenching fires, which happen in the cold ſeaſon. A way of doing this is, by filling with the ſolution hollow balls or cylinders of thin iron, which, upon being thrown into the fire, burſt with great violence, ſcattering the ſalt water all around.

CXXXIII.

Under the Metallurgic branch of chemiſtry are compriſed the ſeveral proceſſes, whereby the metals are extracted from their ores, purified and rendered applicable to a variety of purpoſes.

CXXXIV.

The buſineſs of determining the purity of metals, and other mineral ſubſtances, by experiments made in the ſmall way, conſtitutes a particular art, which is termed the *art of aſſaying*.

CXXXV.

Such experiments made on ores are of great importance, with a view to the correſponding works which are carried on in the large way; ſince by theſe means we are enabled to determine, at a very ſmall expence, whether the latter are likely to be carried on to advantage.

CXXXVI.

To find out the cheapeſt, and beſt adapted proceſs for ſmelting an ore, according to the nature of the mineral, and the circumſtances of the place, is a chemical problem which ſurely is none of the eaſieſt to reſolve.

CXXXVII.

Moſt metals, after they have been extracted from their ores, muſt undergo a variety of other operations, before they can be rendered perfectly pure. Iron muſt be melted again and hammered; copper muſt be purified; ſilver and gold muſt be ſubjected to the teſt, refined from the baſer metals, and ſeparated from one another.

CXXXVIII.

Iron is very much improved by its converſion into ſteel.

CXXXIX.

In the buſineſs of compounding metals great care is required, partly in order to avoid waſte in the operation, partly in order to produce a compound, which ſhall poſſeſs the properties required; partly alſo to prevent any loſs, that might happen to the buyer or the ſeller, for want of a knowledge of their value.

CXL.

Copper combined with zinc produces, according to the different proportions employed,

ployed, braſs, Pinchbeck, ſimilor, and other mixtures; and, when combined with tin, makes bell-metal. With gold and ſilver a certain proportion of it is combined, in order to make them harder. Tin with lead forms pewter; with mercury, it forms the ſubſtance, which, being applied to the back of glaſs-plates, gives them the name of looking-glaſſes.

CXLI.

Aſſays are neceſſary for inveſtigating the nature of all theſe ſeveral compoſitions; particularly of thoſe in which gold, ſilver, or tin are ingredients: and for this purpoſe are inſtituted, in many countries, particular officers, under ſome ſuch name as aſſay-officers, whoſe buſineſs it is to have a vigilant eye upon the goodneſs and genuineſs of thoſe articles.

CXLII.

Metals are brought into the form required, either by melting or by hammering.

In theſe operations, it is neceſſary to know how to manage the fire properly, in order to make ſure, that in the firſt caſe the maſs ſhall receive its proper degree of fluidity; in the ſecond caſe, that it ſhall neither be calcined by the violence of the fire, nor break under the hammer.

CXLIII.

In ſome of the articles that are made in metal, either the ſurface is to receive a poliſh, or a coating of ſome other metal is to be given to it: thus, copper is covered with tin, ſilver is boiled white, braſs is plated over with ſilver, and ſilver with gold. Gold, by being mixed with different alloys, is made to receive different colours, as is ſeen in many of the trinkets that are made of that metal.

CXLIV.

Various metals require alſo various *ſolders*, in order to join one piece to another; as alſo, various coatings, in order to preſerve

ſerve them againſt the effects of the corroſive menſtrum with which air and water are impregnated. To cover copper with ſomething that ſhall render it more ſafe to uſe than it is rendered by the common method of covering it with tin; to cover iron with ſome innoxious ſubſtance that ſhall preſerve it from ruſt, &c. are problems of no ſmall importance to mankind.

CXLV.

The opipeiary manufacturing branch of chemiſtry, treats of the lights that certain arts and manufactures which are carried on in the large way may need from chemiſtry; although they do not, like thoſe hitherto ſpoken of, depend altogether upon that ſcience.

CXLVI.

To this head belong, in particular, the ſeveral proceſſes for preparing furs, leather, hides, ſkins, and parchment; all of which ſtand in need of different methods of treatment, in order to render them fit for their reſpective uſes,

CXLVII.

Furs are prepared with fat, and a ſolution of ſea-ſalt. Thoſe hides, of which the ſkin alone is made uſe of, are prepared with lime or acidulated waters, in order to take off the hair and fat; the hardneſs required is then produced by aſtringents, the ſoftneſs by fat ſubſtances.

CXLVIII.

Theſe proceſſes, when conducted in the common manner, take up a conſiderable length of time; but this might undoubtedly be much ſhortened, ſince, by means of a proper knowledge of the ſubject, leather has actually been as well prepared in four weeks as it commonly is in four months.

CXLIX.

In the woollen manufacture the wool muſt be properly cleanſed; the *chain* properly glued; and the cloth properly fulled.

CL.

In the ſilk manufacture, the rawneſs muſt be taken off from the ſilk, which is entirely a chemical operation.

CLI.

In the linen manufacture, there occur likewiſe ſeveral operations which come under the department of chemiſtry. To this head may likewiſe, with propriety, be referred the preparation of the various ſorts of paper.

CLII.

Different ſorts of glue, ſize, and paſte, are made uſe of for different purpoſes.

CLIII.

For the uſe of engravers, a kind of film or varniſh is required, in order to ſecure the copper from being corroded every where, except in certain places. This varniſh, or etching wax as it is called, ſhould be made in ſuch manner, as that it may be eaſily taken off when done with.

CLIV.

In the diſcharging of ſpots from the ſeveral ſorts of cloths, it is neceſſary to know, in each caſe, not only what menſtrua are adapted to diſſolve and carry off the adventitious ſubſtance, but likewiſe how to chuſe ſuch as are innocent and will do no harm, either to the colour or the ſtuff.

CLV.

The moſt proper and cheapeſt covering for preſerving wood from putrefaction, and for keeping off worms from that part of a ſhip which is under water; the eaſieſt method of detecting adulteration in wines and other merchandiſe, &c. are objects of the greateſt conſequence to the public. Many more examples muſt be continually occurring to a man who pays any degree of attention to the ſubject, on which account we ſhall paſs them over.

CLVI.

From all that has been ſaid, it evidently appears, that, as well in private families as in various manufactories, a multitude of operations are continually occurring, which indubitably are of a chemical nature. They are not, it is true, at leaſt not all of them, indebted to chemiſtry for their having arrived at that degree of perfection to which we ſee them now advanced. Some of theſe arts owe their firſt diſcovery to chance: theſe oftentimes remained a conſiderable time in an unimproved, and, as it were, in a barren ſtate; at laſt ſome man aroſe, who, by a happy combination of courage and ingenuity, ſtruck out improvements, and endeavoured to turn them to account: and thus it has been that proceſſes, which at firſt were altogether imperfect and ill-contrived, by dint of ſlow and ſucceſſive efforts, aided by lights collected from accidental obſervation, have been brought to a ſtate of perfection, far exceeding what could, in thoſe early days, have been expected. But all this buſineſs has commonly gone on very ſlowly, partly becauſe ſuch people only have been concerned, who, deſtitute of all ſcientific acquiſitions, had no choice left but to toil on in the track of blind experiment; partly becauſe theſe employments being all they had to truſt to for their ſupport, they therefore naturally made a point of keeping their invention ſecret, which on that account frequently died with the inventors.

CLVII.

The obtaining of circumſtantial accounts of the progreſs, but more particularly of the preſent ſtate of the arts, cannot therefore fail to be looked upon as a great ſtep towards their improvement. 'Tis from hence that chemiſtry might derive intelligence of many remarkable phenomena, which before were not known but in manufactories. She, on her part, far from being ungrateful, would be always ready to give in return a rich ſtock of uſeful hints and explanations, to all who would think it worth their while to conſult her. It is evident that, ſetting aſide thoſe mechanical changes which are occupied only with the configuration of the ſurface, and therefore have nothing to do here, there can be no other ways of operating on bodies, but either by ſeparating ſomething from them, or compounding them anew: but it is according to the laws of elective attraction [ſee 30], that both ſeparation and combination are performed; conſequently it is from the knowledge of thoſe laws, that the cleareſt lights and moſt effectual aſſiſtances are to be derived. A chemiſt, indeed, cannot create the original materials; yet, by means of ſuch methods as the ſcience teaches him, he can put thoſe materials into ſuch circumſtances, that, according to the different proportions and proceſſes employed, they ſhall become combined in various manners; and by theſe means various bodies ſhall be produced, either ſimilar to ſuch as nature has prepared already, or even altogether new, and both ſorts ſo modified, as to be adapted to the various uſes to which we wiſh to apply them.

OF NATURAL BODIES IN GENERAL.

CLVIII.

Such is the variety of the bodies which compoſe the ſubſtance of this our globe, as cannot, upon a nearer inſpection, but excite our admiration of the infinite power of the Creator.

CLIX.

Upon a general view, theſe bodies may be divided into two great claſſes; one of them compoſed of ſuch bodies as are made up of veſſels and tubes, which carry up or give lodgment to the various juices deſtined to contribute to the growth and nouriſhment of their reſpective bodies. Theſe bodies are called *organized*, and are again diſtinguiſhed into ſuch as poſſeſs ſenſation; to wit, animals, and thoſe which ſeem deſtitute of that faculty, to wit, vegetables.

CLX.

The other great claſs is compoſed of ſuch bodies as are *unorganized*. Theſe are compoſed of parts ſuperficially cohering, which have no internal veſſels or tubes for the conveyance of any nutritious juices, but grow no otherwiſe than by a ſimple juxtapoſition. Of theſe the organic bodies are compoſed, and may accordingly be again reſolved into them. The organic are the work of nature only; the unorganic may alſo be produced by art.

CLXI.

The unorganized bodies may be diſtinguiſhed into ſix kinds: 1. ſalts; 2. earths; 3. inflammable ſubſtances; 4. metals; 5. water; 6. air. Theſe two laſt might perhaps, not without reaſon, be ranked under one or other of the preceding claſſes; but, till we have obtained a more intimate knowledge of them, it may be as well to give them a ſeparate conſideration.

OF SALTS.

CLXII.

The name of ſalt may be given to any body which excites a pungent taſte on the tongue, and combines with water ſo as not to require more than five hundred times its own weight of that menſtruum, when boiling, to diſſolve it.

CLXIII.

The taſte and ſolubility are properties of which it is difficult to fix the limits: the former depends on the perfection of our organs; inſomuch that what appears inſipid to one man, appears ſapid to another, and can therefore never be meaſured with any exactneſs.

CLXIV.

In regard to ſolubility, the degree in which this property is poſſeſſed by bodies, is difficult enough to determine; inaſmuch as it depends partly upon the ſurface of the body to be diſſolved, and partly upon the heat of the menſtruum. It happens, in many inſtances, that a portion of the body in queſtion, which will not diſſolve when entire, may be made to diſſolve only by being reduced to powder; and when the mechanical method of performing that operation proves ineffectual, the purpoſe may oftentimes be effected by a chemical one; to wit, by firſt diſſolving the body in a ſtrong menſtruum, and then ſeparating it in the way of precipitation. The different degrees of ſolubility thus produced, depend, it is evident, on the magnitude of the ſurface; as the greater this is, the more numerous are the points of contact between the ſolvend and the menſtruum, and in that proportion conſequently the force of the attraction is augmented.

CLXV.

Water is the more ſubtle and penetrating the warmer it is. Accordingly, a ſubſtance which does not diſſolve in cold water, is oftentimes diſſolved in warm; and again, a ſubſtance which cannot be diſſolved by ſimple boiling with water in open veſſels, is oftentimes diſſolved in cloſe veſſels, in which the water can be made to imbibe a greater degree of heat.

CLXVI.

By the help of theſe conſiderations it ſhould ſeem, that an artificial boundary might be ſet up, by which ſaline bodies might be diſtinguiſhed from ſuch as are not ſaline, with a tolerable degree of accuracy. Thoſe may be deemed ſaline, which may be made to diſſolve without being reduced to a powder finer than that to which they may be reduced by mechanical means only, and without any more boiling water than five hundred times their own weight, and that in open veſſels (*c*).

CLXVII.

Salts may be diſtinguiſhed into, firſt, the ſimple ones, to wit, thoſe which che-

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(*c*) The productions of nature are linked together, as it were, in an uninterrupted chain; in which, though we can evidently enough diſtinguiſh any two remote links from one another, it is but ſeldom we can diſtinguiſh any two that are contiguous.

miſtry has not yet been able to decompoſe; and, ſecondly, compound, of which the analyſis and ſyntheſis are already known.

CLXVIII.

The ſimple ones are either acids or alkalis.

CLXIX.

Acid is the name given to thoſe ſalts which are ſour to the taſte, which colour blue vegetable juices red, and effervеſce with chalk.

CLXX.

Theſe are further divided into the mineral acids, being ſuch as are obtained chiefly from the mineral kingdom; the vegetable, being ſuch as are obtained from the vegetable kingdom; the animal, being ſuch as are obtained from the animal kingdom; and laſtly, ſuch as are obtained from all kingdoms alike,

CLXXI.

The mineral acids already known are ſix: the vitriolic, the nitrous, the marine, the acid of ſpar, the acid of arſenic, and that of borax (*d*). Theſe, all of them, differ from one another in ſmell, ſpecific gravity, and volatility; but moſt explicitly in reſpect to their different attractive powers, and the compounds they form with alkalis, earths, and metals.

CLXXII.

There are certainly a great variety of vegetable acids, though as yet we are acquainted with but few of them: theſe are the acids that are reſpectively found in ſugar, in tartar, in ſorrel, in lemon-juice, and in vinegar.

CLXXIII.

Of the animal acids that are known, the number is yet ſmaller: they are commonly

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(*d*) To which may be added, the *Acidum Molybdene*, lately diſcovered by Mr. *Scheele*. Act. Stockh. 1778.

reckoned two; to wit, that which is found in ants, and that which is the characteriſtic ingredient in phoſphorus. Yet this laſt is not only found in great quantities in the vegetable kingdom, but has likewiſe been found in certain mineral ſubſtances.

CLXXIV.

The aërial acid is found in all the three kingdoms in large quantities.

CLXXV.

Alkaline ſalts have a peculiar kind of taſte, which, being like that of lixivium of wood-aſhes, may be called lixivious. They change blue juices of vegetables into green, and combine readily with acids.

CLXXVI.

Of alkalis we know only of three ſorts: two of them fixt, the other volatile.

CLXXVII.

The vegetable fixt alkali is obtained commonly from the aſhes of trees, which have deciduous leaves; but the pureſt ſort is obtained from burnt tartar (*e*).

CLXXVIII.

The mineral fixt alkali is found naturally by itſelf in ſeveral places. It may likewiſe be extracted from the aſhes of marine plants, eſpecially from the ſoda.

CLXXIX.

The volatile alkali is obtained the pureſt from ſal ammoniac; leſs pure from animal and vegetable ſubſtances. It has an acrid taſte and fetid ſmell.

(*e*) That which is called pot-aſh has many heterogeneous ſubſtances mixed with it.

CLXXX.

The alkaline ſalts, upon being burnt, loſe a portion of that quantity of aërial acid with which they are generally more or leſs combined. By quick lime, which has a ſtronger attraction for that ſubtle acid, they may be entirely freed from it; and then they are termed cauſtic. In this ſtate they are acrid and corroſive, attract moiſture ſtrongly, produce heat, but do not effervеſce with acids. The more aërial acid they contain, the milder they are, the eaſier to bring to a ſtate of chryſtallization, and the more violently they efferveſce when a ſtronger expels from them this weaker acid.

CLXXXI.

The compound ſalts are diſtinguiſhable into the neutral ſalts, and the ſales medii or middle ſalts; the former do not yield any precipitate upon the addition of an alkali, the latter do.

CLXXXII.

Neutral is the epithet given to thoſe ſalts which conſiſt of an acid united with an alkali. In ſuch combinations the former is frequently called the *menſtruum*, the latter the *baſis*.

CLXXXIII.

If the component ſalts are perfectly ſaturated with each other, they are called *perfectly neutral ſalts*; and of this kind are the greater part of thoſe which, neither in reſpect of their taſte, nor in reſpect of their action on other ſubſtances, reſemble the ſimple ſalts. The caſe is the reverſe with thoſe that are ſtiled the *imperfectly neutral ſalts*, in which one of the elements predominates over the other.

CLXXXIV.

Of the perfectly neutral ſalts, the following are thoſe which are moſt known: the vitriolic acid, combined with the vegetable fixed alkali, gives what is called vitriolated tartar, more properly vitriolated vegetable alkali; with the mineral fixt alkali, Glauber's ſalt, more properly the vitriolated mineral alkali; with volatile alkali, Glauber's ſecret ſalt, more properly vitriolated volatile alkali. The nitrous acid, with the vegetable alkali, makes nitre, or nitrated vegetable alkali; with mineral alkali, cubic nitre, or nitrated mineral alkali; with volatile alkali, inflammable nitre, or nitrated volatile alkali. The marine acid, with vegetable alkali, gives the digeſtive ſalt of Sylvius, more properly ſalited vegetable alkali; with mineral alkali, the common or ſea-ſalt; with volatile alkali, ſal ammoniac, or ſalited volatile alkali. The acetous acid, or acid of vinegar, with vegetable alkali, conſtitutes the *terra foliata tartari*, or acetated vegetable alkali; with mineral alkali, acetated mineral alkali; with volatile alkali, *ſpiritus mindereri*, or acetated volatile alkali.

CLXXXV.

To the claſs of imperfectly neutral ſalts belongs tartar, which conſiſts of vegetable alkali combined with a greater proportion of the acid of tartar than is neceſſary to ſaturate it. Upon ſaturating the acid with the alkali, there reſults a perfectly neutral ſalt, commonly called tartarized tartar, or ſoluble tartar; more properly tartarized vegetable alkali. The borax conſiſts of mineral alkali, which is not perfectly ſaturated with the boracic acid.

CLXXXVI.

The compound neutral ſalts are beſides diſtinguiſhable into ſuch as are double, which are the moſt common; triple, which are compoſed of three elements at once, which is the caſe of the Rochelle ſalt, or ſalt of Seignette; quadruple, &c. &c.

CLXXXVII.

Middle ſalts is the name given to thoſe, of which one only of the elements is ſaline; the other not being by itſelf ſoluble in water, but being rendered ſo by its conjunction with that which is ſoluble.

CLXXXVIII.

If the baſis is an earth [ſee 192], the compound may be called an earthy ſalt; if a metal, a metallic ſalt [ſee 239]. Theſe laſt may almoſt all of them be diſtinguiſhed by means of the phlogiſticated alkali, which precipitates metals diſſolved in acids, each with a peculiar colour.

CLXXXIX.

Each of theſe kinds are again diſtinguiſhable into double ones, triple ones, and ſo forth.

CXC.

The metallic ſalts exhibit yet another diverſity which reſpects the nature of the menſtruum: ſome metals being ſoluble by alkalis as well as by acids.

CXCI.

In our enquiries concerning the chemical nature of bodies, we ought to begin with ſalts; otherwiſe it is like building without a foundation. They are preſent in every part of the œconomy of nature; and there are few, perhaps not any of its operations, that can be carried on without them. Mean time the forms, under which they reſpectively manifeſt themſelves, are in many caſes very different. Some may by themſelves be exhibited in a dry form, others cannot be brought to that ſtate without being rendered almoſt immediately fluid again by the humidity of the air: theſe are termed deliqueſcent ſalts: others are ſuſceptible of cryſtallization: but of theſe again ſome loſe in a dry air a part of the water they took up in cryſtallization, become opake and crumble; ſome require but a little water to diſſolve them, others a great deal, &c. &c.

OF EARTHS.

CXCII.

Earth is the name given to thoſe ſpecies of ſolid matter which remain unaltered in a red heat, without melting or flying off, notwithſtanding they are reduced to the fineſt powder; and which are not ſoluble in open veſſels in a quantity of water leſs than five hundred times their own weight.

CXCIII.

CXCIII.

The earths however are, in many inſtances, ſo far of a ſaline nature as to be ſoluble by means of Papin's Digeſter. This holds good even with regard to quartz. Indeed in the ſtate in which they are found in the ground, they are always combined with an acid, and are therefore in fact, according to their different natures, ſo many ſorts of earthy ſalts [ſee 188]. It would be proper, notwithſtanding, for diſtinction ſake, to arrange them under a different claſs from the one ſo intitled; and this we are enabled to do by means of the diſtinctions above laid down [ſee 192].

CXCIV.

Earths are diſtinguiſhed into ſimple or primitive, and compound or derivative; the laſt being thoſe which conſiſt of two or more ſimple ones combined.

CXCV.

Of ſimple earths there are not as yet known for certainty more than five: ponderous earth; calcareous earth, or lime; magneſia; argillacous earth, or clay; and ſilicious, or cryſtalline earth: all which may eaſily be diſtinguiſhed from one another by means of the phenomena they reſpectively exhibit, when combined with vitriolic acid.

CXCVI.

Theſe five no one as yet has been able either to decompoſe, or to tranſmute one into another.

CXCVII.

The ponderous earth forms with vitriolic acid ponderous ſpar, which is not ſoluble in a thouſand times its own weight of boiling water.

CXCVIII.

For any thing we know as yet, it is but ſeldom that this earth makes its appearance. There are many reſpects in which it reſembles calcareous earth: for example, inaſmuch as it unites with the aërial acid, efferveſcing thereupon with other acids; loſes its aërial acid by expoſure to fire, becoming thereupon ſoluble in water, but ſeparating again from the water in open air, in the manner of the *cremor calcis*; and, when burnt, renders alkalis cauſtic, and combines with ſulphur, &c.

CXCIX.

There are other reſpects, however, in which it ſhows itſelf quite different: with the nitrous and marine acids it forms ſalts, which are ſuſceptible of cryſtallization, and which require a large proportion of water to diſſolve them; at the ſame time that the compounds it forms with acetous acid are deliqueſcent:

deliqueſcent: in both which particulars the phenomena exhibited by calcareous earth with the ſame acid, are entirely different. Another thing is, that the attraction which ponderous earth has for vitriolic acid is ſo ſtrong, that it ſeparates that acid even from the vegetable alkali; which is what never is done by calcareous earth: not to mention a variety of other circumſtances.

CC.

Calcareous earth, combined with vitriolic acid to the point of ſaturation, forms *Gypſum*, which is ſoluble in five hundred times its own weight of boiling water. Gypſum is known by the property it has of forming, after a ſlight burning, a hard maſs with water.

CCI.

Calcareous earth is found in great abundance, but commonly ſaturated with aërial acid, which exhibits the appearance of effervеſcence upon being driven from its baſis by a ſtronger acid. Calcareous earth is found diſſolved in moſt waters, by means of a redundant portion of the aërial acid. By burning it loſes that acid, together with a proportion of water, which it was combined with, and enters into a chemical combination with a certain quantity of the matter of heat, in which ſtate it is called quick lime; an article abſolutely neceſſary in bricklayers work and maſonry. Its having a greater attraction for water than for the matter of heat, is the reaſon, that when the quick lime meets with the former, it lets go the latter; by which means a great quantity of ſenſible heat is produced, converting a part of the water which it has abſorbed into vapours; which, if the calcareous earth were in the form of a ſtone, would break it down into a fine powder.

CCII.

Magneſia ſaturated with vitriolic acid forms a bitter ſalt, known under the names of Engliſh, Epſom, Seydſchutz, or Seidlitz ſalt. Although the ſalts known under theſe different names differ from one another on account of ſome heterogeneous ſubſtance which is combined with them, yet the vitriolated magneſia is the characteriſtic and principal ingredient in them all.

CCIII.

Magneſia is ſeldom found alone, but there are ſeveral kinds of ſtones of which it commonly forms a conſtituent part. It is contained frequently in freſh waters, by means of a quantity of aërial acid which is diſſolved in them; and in ſea-water it is preſent in vaſt quantities, united with the marine acid. When ſaturated with aërial acid, it effervеſces upon the application of a ſtronger acid. In the fire it parts eaſily with its aërial acid, but does not thereupon become ſoluble in water, as cauſtic calcareous earth does. It may be made to diſſolve ſulphur, but with difficulty, and that only in ſmall quantities.

CCIV.

Pure argillaceous earth, diſſolved with a ſcarce perceptible ſuperabundance of vitriolic acid, forms alum.

CCV.

This earth is met with in vaſt quantities, but always mixed with a greater or leſs proportion of heterogeneous matters, eſpecially with ſand or ſilicious earth. The tenacity it poſſeſſes when mixed with a due proportion of thoſe laſt-mentioned ſubſtances, and the property it has of becoming hard by burning, render it fit for being made into bricks and tiles, and ſeveral other implements.

CCVI.

The four kinds of earth above deſcribed might alſo be called *abſorbent*, as they all abſorb a quantity of aërial acid, exhibiting, upon the application of a ſtronger acid, an effervefcence, which however is much leſs conſpicuous in the argillaceous earth than in any of the others.

CCVII.

The ſilicious earth is not affected by the vitriolic acid; it is, however, diſſolved by that of ſpar.

CCVIII.

This is found every where in great quantities: in the rock cryſtal and tranſparent quartz it is perfectly pure. With alkalis it is brought into fuſion in the dry way very readily; and, by its union therewith, conſtitutes that moſt uſeful manufacture which is called glaſs. That the acid of ſpar is a conſtituent part of the ſilicious earth there is no doubt; but the baſis of it is not yet perfectly known. It ſeems however to be the fixt part of water; ſince by that acid and water together, the earth in queſtion may be produced by art even in a cryſtalline form.

CCIX.

Of two or more of theſe five kinds of ſimple earths, all the others which have yet been examined, have been found to be compounded; the diamond excepted, which, in an open fire, evaporates entirely, or, to ſpeak more properly, burns; ſince it goes off by degrees with a ſmall flame, exhibiting likewiſe ſome ſigns of ſoot. This ſtone, which is of all known ſubſtances the hardeſt and moſt ſcarce, affords, at the ſame time, the moſt obſtinate reſiſtance to all menſtruums whatſoever, and contains probably a peculiar kind of earth, which might be called noble earth, but the nature of which remains yet to be aſcertained by diligent and exact experiments. Quite different is the nature of the ruby, the ſapphire, the topaz, and the emerald: theſe are each of them compounded of argillaceous, ſilicious, and calcareous earth; of which the firſt is the moſt abundant, and the laſt preſent only in a very ſmall quantity.

tity. The different colours they poſſeſs, to wit the red, the blue, the yellow, and the green, are all derived from iron; which, for the different appearances it exhibits, ſtands indebted probably to its being differently modified by different proportions of phlogiſton.

OF INFLAMMABLE SUBSTANCES.

CCX.

To this claſs belong all thoſe bodies which are conſumed by burning.

CCXI.

The foundation of this property of inflammability lies, properly, in a very ſubtle matter, which the ancients called phlogiſton; ſo ſubtle indeed, that, were it not for its combination with other ſubſtances, it would be imperceptible to our ſenſes. It can, however, be made to migrate from one body into another, according to the laws of elective attraction; and it is by the changes it thereupon exhibits, and them only, that we learn ſo much as we are acquainted with of its nature. It is preſent probably, more or leſs of it, in all bodies; it renders, however, thoſe alone inflammable, in which it exiſts in abundance, and with which, at the ſame time, it is not ſo ſtrongly united, but that it may be driven out from them in great quantities under certain circumſtances, by the ruſhing in of air.

CCXII.

Phlogiſton, united with vitriolic acid to the point of ſaturation, forms what is commonly called ſulphur.

CCXIII.

If ſulphur be diſſolved in an alkali, the compound is called liver of ſulphur, or *hepar ſulphuris*. This ſubſtance has the ſmell of rotten eggs, eſpecially upon the application of an acid; in which caſe the ſulphur is precipitated. It diſſolves in water and ſpirit of wine.

CCXIV.

The ſolutions of ſulphur in the ſeveral kinds of oils are called balſams of ſulphur; they have a diſagreeable ſmell, and in conſiſtence they are thinner or thicker, according as the proportion of ſulphur diſſolved in them is leſs or greater.

CCXV.

Phoſphorus alſo is a ſpecies of ſulphur: but this conſumes in a free air ſo ſlowly and gently, that letters written with it continue to give light in the dark for a long time together. It is compoſed of phlogiſton and a peculiar kind of acid, which taking its name from the compound in queſtion, is called *phoſphoric* acid. This ſpecies of ſulphur muſt be kept in water, as in the open air it very ſoon conſumes.

CCXVI.

The other acids no one as yet has been able to combine with the phlogiſton, in ſuch manner as for them to form ſolid ſulphur.

CCXVII.

Pyrophorus is the name given to a powder compoſed of alum and a little phlogiſton, which begins to burn of itſelf, as ſoon as it is expoſed to the open air. This phenomenon depends probably upon ſome hepatic principle, generated during the preparation of the powder.

CCXVIII.

The Bolognian Phoſphorus is a name given to the ponderous ſpar, or *ſpathum ponderoſum* [ſee 197], which has been ignited upon live coals, and has thereby received the power of attracting a quantity of light, which it emits afterwards in the dark.

CCXIX.

Baldwin's *Phoſphorus* poſſeſſes the ſame property, but is prepared from chalk diſſolved in nitrous acid; which compound is evaporated to dryneſs, and then made to undergo a certain degree of ignition.

CCXX.

The ſparry fluor, or *fluor ſpathoſus*, alſo yields, when heated by degrees, a fine phoſphoric light, which is likewiſe yielded by ſeveral other ſubſtances, although in a weaker degree. Sugar, the ore called *pſeudogalena*,

dogalena, &c. give light in the dark upon being rubbed.

CCXXI.

Oil is the name given to certain greaſy liquids, which do not mix with water, which are ſuſceptible of combuſtion; yield a great deal of flame and ſmoke in burning, and leave a coal behind them when they are burnt out.

CCXXII.

The elements they are compoſed of are phlogiſton, aërial acid, and water.

CCXXIII.

They are diſtinguiſhed into two kinds, the unguinous and the eſſential.

CCXXIV.

Unguinous is the name given to thoſe which are without ſmell and taſte, are not ſoluble in ſpirit of wine, nor volatile in the heat of boiling water.

CCXXV.

If theſe oils are forced over in diſtillation by a ſtronger heat, they acquire a burnt ſmell and taſte, and become ſoluble in ſpirit of wine: in this ſtate they are called empyreumatic, and ſometimes philoſophical oils.

CXXVI.

Tallow, butter, and other animal fats, are ſimilar to unguinous oils in moſt reſpects.

CCXXVII.

Eſſential oils have a ſtrong taſte and ſmell, of which the latter is commonly moſt agreeable. They are ſoluble in ſpirit of wine, and volatile in the heat of boiling water.

CCXXVIII.

The principle to which they owe their ſmell, is a very ſubtle oleaginous fluid. This is called their *ſpiritus rector*; it flies off in time, and in proportion as this happens, the oils loſe their ſmell, and become viſcid and heavier than they were before.

CCXXIX.

Dippel's animal oil muſt not be confounded with the common animal oils mentioned in § 226: it is obtained by diſtillation from the gelatinous ſubſtance of animals. It is at firſt of a deep brown colour, tenacious conſiſtence, and empyreumatic ſmell: but it may, by repeated rectifications, be brought to ſuch a degree of limpidity as to reſemble ether [ſee 231]: but if the air is ſuffered to have acceſs to it, it grows brown again.

CCXXX.

The oils break out into a flame upon the application of nitrous acid: a pleaſing and ſingular appearance, to be produced by the mixture of two cold fluids.

CCXXXI.

Ether is the name given to a ſubtle oil, which combines with ten times its weight of water, has an agreeable refreſhing ſmell, and burns ſtrongly, giving ſome ſigns of ſoot, but not leaving any coal behind. Its volatility is ſo great, as to turn water into ice in a warm room: for all evaporation produces cold, in proportion to the celerity with which it is carried on. Ether takes gold from the ſolution of it in aqua regia, and has the property alſo of diſſolving the elaſtic reſin.

CCXXXII.

Hoffman's anodyne liquor is a ſolution of ether in ſpirit of wine.

CCXXXIII.

Spirit of wine is a fluid inflammable ſubſtance, which combines with water in every proportion, burns without ſoot, and without leaving a coal behind it.

CCXXXIV.

It conſiſts of phlogiſton and water, which are probably united together by the intervention of an acid; when deprived as much as poſſible of all ſuperfluous water, it is called alkohol.

CCXXXV.

Of bodies which deflagrate with great violence and noiſe, there are ſeveral preparations: the three following are the moſt remarkable.

CCXXXVI.

Gunpowder is a compoſition made of nitre, ſulphur, and charcoal in certain proportions: that of the firſt being the largeſt, and commonly three-fourths of the whole. The charcoal and ſulphur are no otherwiſe neceſſary, than to make it burn ſo much the quicker; and it is the nitre only, properly ſpeaking, that makes the exploſion. This ſalt burns with great violence, whenever it touches an inflammable body in a ſtate of ignition.

CCXXXVII.

Pulvis fulminans, or thundering powder, is a mixture of three parts of nitre, two of the alkali of tartar, and one of flowers of ſulphur. It explodes with a violent report when melted in an iron ſpoon over the fire. It ſeems as if this effect depended on the detonation of the hepar ſulphuris generated during the fuſion: for nitre with half its weight of hepar ſulphuris makes the ſame report.

CCXXXVIII.

Aurum fulminans conſiſts of gold which has been diſſolved in *aqua regia*, and precipitated by volatile alkali. This precipitate, when edulcorated, dried, and then heated to a certain degree of heat, gives a prodigious report. It may even be prepared in ſuch manner as to explode, by being only ſhaken about a little in a piece of paper.

OF METALS.

CCXXXIX.

Metals are ſhining opake bodies, which are heavier than all others: the lighteſt of them being ſix times the weight of water, and ſome of them almoſt twenty times its weight.

CCXL.

The metals with which we are at preſent acquainted, are fifteen in number, viz. gold, the ſpecific gravity of which is to that of water as $19\frac{1}{2}$ to 1; platina as 18; quickſilver as 14; lead as $11\frac{4}{10}$; ſilver as 11; viſmuth as $9\frac{8}{10}$; copper as $8\frac{8}{10}$ nickel; as $8\frac{5}{10}$; arſenic as $8\frac{1}{10}$; iron as 8; cobalt as $7\frac{7}{10}$; tin as $7\frac{7}{10}$; antimony as $6\frac{7}{10}$; and mangaueſe, the ſpecific gravity of which has not as yet been exactly diſcovered (*f*).

CCXLI.

Metals are compounds formed of phlogiſton and ſo many different kinds of earths, which are termed the calces of the reſpective metals, and have no ſimilitude with any of the earths above deſcribed [ſee 192 to 209].

(*f*) According to the lateſt diſcoveries of Mr. *Bergman*, about as $6\frac{8}{35}$.

CCXLII.

Thoſe metals, in which the phlogiſton and the calx have ſo ſtrong an attraction for one another as not to be ſeparated in an open fire, are called the *noble metals*. In the humid way indeed they may be calcined; but when a certain degree of fire is applied, they are thereby alone, without any addition being neceſſary, made to reaſſume their metallic form.

CCXLIII.

To this diviſion belong *gold*, *platina*, and *ſilver*.

CCXLIV.

The *baſe* or *ignoble metals*, on the other hand, are thoſe which loſe in an open fire their metallic form, and are changed thereupon into a powder, reſembling an earth; which powder reſumes not in the fire its metallic form, without the application of an inflammable body.

CCXLV.

To this diviſion then belong the remaining metals, quickſilver excepted, which is, as it were, of a middle nature between that of the noble and the ignoble metals: ſince, on the one hand, it may by fire, like the latter, be calcined; but, on the other hand, like the former, it may, without any addition, be reduced again to its metallic form.

CCXLVI.

Some of the metals are malleable, and to theſe alone, ſtrictly ſpeaking, does the name of metal properly belong. Gold is capable of being extended to a ſurprizing degree: inſomuch that 651,590 cubic inches, may be covered with a cubic inch of it. Lead is the leaſt malleable. Platina, ſilver, copper and iron, come between.

CCXLVII.

Quickſilver is as much a metal as any of them: for when reduced to ſolidity by a certain degree of cold, it is malleable nearly in the ſame degree as lead.

CCXLVIII.

Semi-metal is the name given to all metallic ſubſtances, which break under the hammer. Zinc is the moſt malleable of them all; nor will it ſuffer itſelf to be reduced to a powder ſo readily as the others; to wit, viſmuth, nickel, arſenic, cobalt, antimony, and manganeſe.

CCXLIX.

Viſmuth, antimony, and arſenic, upon being broken, appear to be of a foliated texture: the reſt appears to be more or leſs finely granulated.

CCL.

The colour of them is of various hues: gold is yellow; copper of a reddiſh yellow; nickel and viſmuth bear a little towards a whitiſh red; platina, ſilver, quickſilver, tin, and antimony are white; lead, zinc, iron, cobalt, arſenic, and manganeſe, verge towards the blue or green.

CCLI.

The metals require a very different degree of heat to melt them: quickſilver ſo little, that the atmoſphere is ſcarce ever without a quantity ſufficient for that purpoſe; the reſt ſtand in point of fuſibility in the following order: tin, viſmuth, lead, zinc, arſenic, antimony, ſilver, gold, cobalt, nickel, copper, iron, manganeſe, and platina; which laſt, without previous preparation, can no otherwiſe be brought into fuſion but by a burning mirror.

CCLII.

It is remarkable, that ſome metallic compoſitions become more fuſible than any of their component metals: lead, tin, and viſmuth, combined in a certain proportion, are fuſible in the heat of boiling water.

CCLIII.

Six metallic ſubſtances are volatiliſable by fire: quickſilver, arſenic, zinc, antimony, lead and copper.

CCLIV.

Zinc and arſenic are inflammable: the former burns with a beautiful green flame. Copper and gold exhibit alſo during their fuſion a greeniſh luſtre.

CCLV.

All metallic ſubſtances are capable by themſelves of being united with ſulphur, gold and zinc excepted; which cannot be united with it but by the intervention of ſome third ſubſtance, which has a common attraction for both the elements that are to be combined.

CCLVI.

A metallic ſubſtance is ſaid to be mineralized, when, by being combined with ſulphur, it has loſt its metallic form.

CCLVII.

The metallic calces are capable of being vitrified, and in that ſtate give the different colours which are uſed in enamel.

CCLVIII.

White arſenic is the calx of the ſemi-metal ſo called, which diſſolves in water. It may alſo be entirely freed from its phlogiſton, and is then found to be a particular kind of acid. This gives us occaſion to ſuſpect, that the other metallic calces are all of them but ſo many particular kinds of acids, which continue to retain the quantity of phlogiſton, which is neceſſary to inſpiſſate them, and enable them to retain their ſolid form. By reflection and perſeverance we may one day, perhaps, find means to overcome that attraction, which prevents us, as yet, from ſetting free the acids of the other metallic calces.

CCLIX.

When the metallic calces are made to loſe a great portion of their phlogiſton, they are either not ſoluble at all by acids, or at leaſt not without great difficulty. As little can a metallic ſubſtance be diſſolved, ſo as to retain its whole quantity of phlogiſton. In order for a ſolution to take place, it is neceſſary that the metal ſhould poſſeſs a certain quantity; more or leſs than which would equally prevent the effect. A moſt eminent inſtance of this, is that of manganeſe; which, when it is in its metallic form, muſt always part with a quantity of its phlogiſton before it is capable of being diſſolved; but, when it is in the form of a white calx, is diſſolved without any ſuch loſs; and at laſt, when calcined to blackneſs, is not attacked by acids at all, unleſs a quantity of phlogiſton be reſtored to it.

CCLX.

The ſcience which furniſhes us with diſtinct and certain characters, by which the ſeveral ſorts of ſalts, earths, inflammable bodies, and metallic ſubſtances, may be diſtinguiſhed from one another, has received the name of *mineralogy*.

OF WATER.

CCLXI.

Water is a ſubſtance that exiſts every where: we find, accordingly, that nearly the half of the ſurface of our globe is covered with it.

CCLXII.

We can hardly frame to ourſelves any other general idea of a fluid body, than that it conſiſts of a quantity of infinitely fine and ſolid particles, which, by reaſon of their fineneſs, and the weakneſs of their attraction of coheſion, are ſo eaſily moved one over another, that the whole aſſemblage of them tends conſtantly to maintain a horizontal ſurface. Something of this ſort is ſeen even in ſand; which, in ſome places, is ſo fine, that a man may, as it were, be drowned in it. If then the interſtices of ſuch a fluid be filled up by one ſtill finer, the particles acquire ſtill a greater degree of mobility; and this is preciſely the caſe with water.

CCLXIII.

Heat is that fluid which augments the fluidity, not only of water, but alſo of all other ſubſtances: and according to the quantity of it which water poſſeſſes, it appears to us in three different forms.

CCLXIV.

If the quantity of the heat in water is ſo ſmall, as not to raiſe the mercury in *Celſius*'s thermometer above the degree which is marked O, the particles of the water loſe their faculty of ſliding over each other, adhere together, and form a ſolid, clear, and elaſtic maſs, which is lighter than the water was before, and which is known to us under the name of ice.

CCLXV.

That the particles upon this occaſion endeavour to cryſtallize, or range themſelves into a certain order, is evident; and this is one capital reaſon why the maſs expands itſelf, and occupies a larger ſpace.

CCLXVI.

When ice thaws, it is found to contain as much ſenſible heat as is indicated by *Celſius*'s thermometer, when the mercury ſtands at 72 [ſee 297]. This quantity of heat is the leaſt which is neceſſary to reſtore the ſubſtance to a fluid ſtate; and any farther addition augments its fluidity in proportion to the quantity that is added.

CCLXVII.

Water in its fluid ſtate is ſuſceptible of compreſſion, though but in a ſmall degree.

CCLXVIII.

But when the aqueous particles receive a ſuperabundant portion of ſenſible heat, over and above what is neceſſary to bring them to a liquid ſtate, they are converted into elaſtic vapours; which change takes place in a moſt remarkable degree, when the maſs is at the heat of boiling water. In that degree of heat, a given quantity of water does ſo far expand itſelf, as to occupy fourteen thouſand times the ſpace that it did before, and thereby obtains a proportionably greater number of points of contact with the matter of heat; which thence is capable of being united with it in a larger proportion. And this ſeems to be the way in which that degree of cold is produced, which may be obſerved conſtantly to take place upon evaporation. This union however is again deſtroyed upon refrigeration.

CCLXIX.

As in all degrees of heat above O vapours are generated continually, it follows, that the particles, in order to aſſume an elaſtic form, ſtand not in need of any very conſiderable quantity of heat; but only the leſs heat they have, the leſs they are elaſtic.

CCLXX.

If it be aſked which of all theſe forms [ſee 264 to 269] are moſt natural to water? the anſwer is, that they are all natural to it alike. But if the queſtion be, in which of them the water is freeſt from all heterogeneous particles? the anſwer is plainly, in that of ice.

CCLXXI.

Whether the primary elemental particles of water are homogeneous with reſpect to each other, or heterogenous, is difficult to aſcertain: yet the latter opinion does not ſeem to be inconſiſtent with the plan purſued by nature with reſpect to other ſubſtances.

CCLXXII.

That theſe particles, in the common courſe of nature, can be ſo modified as to be made to loſe their ordinary ſtate with reſpect to attraction, ſo as to exhibit themſelves in the form of an earth, ſeems alſo to be not incredible; but that the experiments which have as yet been cited in ſupport of this propoſition, do not prove any ſuch thing, is evident enough.

CCLXXIII.

The diſſolvent power of water is one reaſon why it is always found more or leſs loaded with heterogeneous particles; of which ſome, by reaſon of their fineneſs, hang ſuſpended in it, while others perhaps, are, properly ſpeaking, diſſolved in it.

CCLXXIV.

In the mechanical way may be mixt with it any ſort of ſolid ſubſtances whatever, when reduced to a certain degree of fineneſs; and theſe may alſo remain ſuſpended in it, when the friction which they would have to overcome, before they could fall to the bottom, becomes greater than the overplus of their ſpecific gravity with reſpect to water.

CCLXXV.

The ſubſtances which water is capable of containing in a ſtate of ſolution, may be diſtinguiſhed, in a general point of view, into ſuch as are volatile and ſuch as are fixt.

CCLXXVI.

Of the former of theſe claſſes are; firſt, pure air [ſee 283]; ſecondly, aërial acid [ſee 337]; and thirdly, hepatic air [ſee 308].

CCLXXVII.

Of the latter or fixed kind there are various ſoluble ſubſtances: theſe, however, are ſeldom of the ſimple kind, but commonly either the neutral or middle ſalts: for example, vitriolated vegetable alkali, or more commonly, vitriolated mineral alkali. In the ſame manner are found the ſeveral compounds of vitriolic acid with calcareous earth, with magneſia, and ſometimes with clay, iron, copper, and zinc. Thoſe of nitrous acid with vegetable alkali; ſeldom thoſe of the ſame acid with mineral alkali; ſometimes thoſe with calcareous earth and magneſia; ſeldom thoſe of marine acid with vegetable alkali; often thoſe of the ſame acid with mineral alkali, calcareous earth, and magneſia; thoſe of the aërial acid with mineral alkali, calcareous earth, magneſia, and iron.

OF AIR.

CCLXXVIII.

The inviſible fluid which every where ſurrounds our globe, is commonly called the air, or, more properly, the atmoſphere;

as it is a mixture of a variety of ſubſtances, which agree; indeed, inaſmuch as they are all of them of a ſubtle, elaſtic, tranſparent, and fluid nature, and in point of ſpecific gravity near eight hundred times lighter than water; but which, in a variety of other reſpects, are found to be very different.

CCLXXIX.

Of late days we have began to comprehend, under the name of airs, all ſorts of ſubſtances, which, being of a tranſparent, elaſtic, homogeneous, ſubtle, light, and fluid nature, retain their aërial form in the greateſt cold to which they are known to have been expoſed. When the nature of theſe comes to be thoroughly known, there can be little doubt but that they may all of them be brought under one or another of the before-mentioned diviſions [ſee 161]; which already is the caſe with great part of them [ſee from 308 to 342]. In the mean time, there will be a convenience in continuing them under their preſent name, ſince thereby we have the advantage of placing them altogether under one point of view.

CCLXXX.

Vapours is the name that may be given to all thoſe elaſtic fluids, which loſe by cold their aërial form, and re-aſſume again that which belonged to them before the heat, which they had imbibed, had endued them with that extraordinary degree of ſubtlety and elaſticity. The vapours of water are condenſed during the courſe of their refrigeration into drops, which conſiſt of water, as before. The ſame thing happens with regard to the vapours of other ſubſtances.

CCLXXXI.

There are a great variety of different ſorts of vapours. All bodies liquid in the heat of the atmoſphere, may be brought into ſuch a ſtate; as alſo all ſolid bodies, if not with reſpect to the whole of their maſs, at leaſt with reſpect to certain parts of it. According to the nature of the ſoil, the climate, the ſituation, and a variety of other circumſtances, the atmoſphere muſt therefore become a kind of place of rendezvous for a multitude of different vapours; which not only give occaſion to thaw, rain, hail, and ſnow, but alſo, according to their different qualities and mixtures, to the ſeveral ſorts of lights, exploſions, and coruſcations, which are wont to be comprehended under the general name of meteors.

CCLXXXII.

Setting aſide vapours, which are continually varying, as well in point of quality as quantity, the atmoſphere (as far as we have reaſon to believe), contains every where, and at all times, three different kinds of aërial fluids; viz. pure or aphlogiſtic air, phlogiſticated air, and aërial acid; and the mixture, compoſed of all theſe three, may go under the name of common air.

CCLXXXIII.

At the ſurface of the earth, the pure air conſtitutes not more than $\frac{1}{4}$, or, at moſt, not more than a third, of the bulk of a given quantity of common air; at the ſame time, the proportionable quantity of this pure air is undoubtedly a matter of the higheſt importance to every thing that breathes.

CCLXXXIV.

It is this air only that is fit for animals to breathe; and which is ſo neceſſary to fire, that, without it, the inflammation ceaſes in a moment.

CCLXXXV.

In reſpect to theſe properties, it has nearly eight times the power of common air [ſee 226 to 228].

CCLXXXVI.

CCLXXXVI.

The nature of it, as to what concerns its origination, is not yet determined. The ſtrong propenſity it has to attract phlogiſton, affords ſome reaſon for ſuppoſing it to be acidulous; but it makes no change at all in the colour of the tincture of lacmus [*gummi laccæ*]. Notwithſtanding this, it contains aërial acid; which may be precipitated from it, as well by electricity, as by other proceſſes which have the effect of impregnating it with phlogiſton. Hence it ſhould ſeem, that aërial acid forms exactly one conſtituent part of it; and the reſt muſt conſequently be ſomething which has the property of laying hold of an acid, and entering into an intimate union with it, but yet has a ſtill ſtronger attraction for phlogiſton.

CCLXXXVII.

Beſides that portion of the aërial acid which enters into the internal compoſition of pure air, there is alſo always found in the common air a ſmall portion, which is free and uncombined; but which ſeldom, however, conſtitutes more than $\frac{1}{16}$ part of the whole bulk of common air.

CCLXXXVIII.

This looſe portion of aërial acid is eaſily ſeparated from the reſt of the air, by only making it paſs through a lixivium of cauſtic alkali, or lime-water. It is alſo, by means of this acid, that ſuch lixivia, upon being expoſed to the open air, gradually become milder and milder, till at length they cryſtallize; and that lime-water alſo comes to throw up the pellicle [*cremor calcis*] on its ſurface.

CCLXXXIX.

The aërial acid is altogether unfit for reſpiration, inſomuch that it kills animals inſtantaneouſly, putting an end, at the ſame time, to all irritability, even to that of the heart. In an inſtant it alſo extinguiſhes fire. Water abſorbs it to ſuch a degree, as to take up a bulk of it equal to its own, and is thereby rendered acidulous.

CCXC.

The third and remaining portion of the common air, which is ſtill greater than both the two former put together, is altogether unfit, as well for reſpiration as combuſtion; and is moreover not abſorbed by water.

CCXCI.

The true nature and compoſition of this part of the air is not yet determined; but ſince the pure air is entirely ſpoilt and rendered unfit, as well for further reſpiration as for combuſtion, by having been breathed, by having been made ſubſervient to the deſtruction of inflammable ſubſtances by fire; as alſo by having received the effluvia of bodies in the ſtate of putrefaction, and by other proceſſes, in which a great quantity of phlogiſton is diſengaged, there is great reaſon to look upon it as phlogiſticated. If this is really the caſe, thoſe who inhabited the globe immediately after its creation, muſt, it ſhould ſeem, have breathed a much purer air than we do now, when animals, fires, and putrefactions, &c. have, for ſo many thouſand years, been contributing to its depravation. Might not this, perhaps, be the cauſe of the longevity of the firſt inhabitants of our globe?

CCXCII.

But if it be true, that the quantity of pure air is thus undergoing a continual diminution, it ſhould ſeem, at firſt ſight, that at length it muſt be ſo far reduced, that all animals muſt be ſuffocated, and all fires extinguiſhed. Nature, however, has probably made ſome ſort of proviſion for reſtoring and purifying depraved air, at leaſt in part. It has been ſuppoſed, that this might be effected by agitation with water, and that ſuch a proceſs is actually carried on in the large way, by the continual motion of the ſea; and further, that vegetables, in growing, ſeparate and abſorb the depraving matter. This important queſtion will, it is to be hoped, be decided by further and more accurate experiments.

CCXCIII.

Although pure air, combined with a certain quantity of phlogiſton, ſeems to conſtitute the ſame ſort of noxious ſubſtance which depraved air is; we have, notwithſtanding, reaſon to believe, that the matter of heat (that ſubſtance which is ſo indiſpenſibly neceſſary to all living creatures) is no otherwiſe produced than by the union of pure air with a certain different proportion of phlogiſton. That the ſame elements, combined in different manners, or in different proportions, may produce different bodies, is already pretty well proved in various inſtances.

CCXCIV.

It is alſo, at this time, by a multitude of experiments, put out of doubt, that heat conſiſts merely in an internal motion taking place among the particles of the ſeveral ſorts of ſubſtances that are ſuſceptible of it. It is, on the contrary, a ſubſtance *ſui generis*, a particular ſubtle kind of fluid, which penetrates or pervades all, even the denſeſt bodies, and thereby, according to its quantity, produces thoſe particular ſenſations in animals, which are called cold, warmth, and heat.

CCXCV.

Fire is therefore neither more nor leſs than that ſtate of inflammable bodies, in which the greater part of the phlogiſton, which enters into their compoſition, is torn away by means of the pure air, with great force and violence from thoſe particles with which it was before combined. This, then, is the way in which a great quantity of heat, or what comes to the ſame thing, what we call fire, muſt neceſſarily be produced [ſee 293]. As to the flame, it is, properly ſpeaking, generated from inflammable air [ſee 298]; which, in theſe circumſtances, is detached from all inflammable bodies in great quantity, and very readily takes fire.

CCXCVI.

As to the light, which in theſe circumſtances is alſo always generated, it appears probable, from a variety of experiments and obſervations, that this ſubſtance is compoſed of heat, charged with a certain over-proportion of phlogiſton. He who conſiders in what different forms water ſhows itſelf when in a liquid ſtate, and when in a ſtate of vapours, and that owing to no other cauſe than the different quantities of heat which it contains, will hardly pronounce it abſolutely incredible, that a different proportion of phlogiſton ſhould convert heat into light; although he ſhould not yet have been informed of the reaſons by which that propoſition is made out.

CCXCVII.

Heat, then, being a ſubſtance, is, like other ſubſtances, ſubject to the laws of attraction. Accordingly, when it is preſent in bodies in ſuch a manner as to form a conſtituent part of them, that is, to be in a ſtate of chemical combination with the other elements of which they are compoſed, the power which it has, in other circumſtances, of exciting the ſenſation of warmth, is found to be compleatly maſked, as it were, and ſuſpended, in the ſame manner as the characteriſtic properties of an acid are by combination with an alkali. Hence it comes, that, upon the decompoſition of ſuch bodies, a ſenſible heat or warmth is produced: the matter of heat, which before was fixt, being now diſengaged or ſet at liberty, by a more powerful attraction.

CCXCVIII.

Inflammable air is the name given to that ſort of air, which, upon the application

tion of a body in a flaming ſtate, takes fire immediately, exhibiting alſo the appearance of a flame. When a bottle is filled perfectly full of pure inflammable air, the air muſt be ſet on fire, and deflagrated ſeveral times, before it is entirely conſumed.

CCXCIX.

It may be ſet on fire not only by a flame, which never fails, but alſo by a burning coal, by a red-hot iron, by ſparks of the electrical kind, and by ſuch as are produced by the colliſion of a flint with a piece of ſteel. Hence it is, that ſmall piſtols have been loaded with inflammable air, and then fired by electricity; in which caſe the ſpark need not be ſtronger, than what is ſufficient to ſet on fire ſpirit of wine.

CCC.

If common air be mixed with inflammable, it makes a report in burning, and the whole goes off at once.

CCCI.

Inflammable air mixed with nitrous [ſee 321], deflagrates with a green flame; but with aërial acid it will not mix at all.

CCCII.

An electrical ſpark, paſſing through inflammable air, appears of a purpliſh red.

CCCIII.

Inflammable air is obtained from all the three kingdoms of nature, often without any other proceſs than the application of a ſtrong fire: each different kingdom, however, gives a different ſmell to the air which is derived from it. It is alſo obtained from certain metals, by ſolution in the vitriolic and marine acids. It turns ſilver black.

CCCIV.

The ſort of inflammable air which is afforded by organized bodies, is diſtinguiſhed, by certain circumſtances, from that which is obtained from ſuch as are not organic. That which is obtained from mineral bodies, requires, in order to produce the ſtrongeſt report, an admixture of no more than $\frac{2}{3}$ of its bulk of common air; and of pure air, only one half: in which laſt caſe, the report is from forty to fifty times as loud again as in the former; whereas that which is produced from organic bodies, requires an addition from ten to twelve times its bulk of common air, in order to deflagrate at once. With regard to the flame, this in the former kind of inflammable air is of a red caſt, in the latter of a blue.

CCCV.

In marſhes, ponds, and rivers, where the ſoil underneath contains ſubſtances in a ſtate of putrefaction, ſuch an air, upon ſtirring the ground under the water, will often riſe in ſuch a quantity, as to take fire on the ſurface of the water, upon the application of any burning body. It ſeems to be this air, that, when mixed with the reſt of the atmoſphere, and ſet on fire by the electricity of the clouds, occaſions the phenomena, which are called Will o' the wiſps, and falling ſtars.

CCCVI.

Vegetables grow in this air, but the inflammability of it is not thereby increaſed. Animals die in it; and a lighted candle, when plunged below the ſurface of it, goes out.

CCCVII.

The nature and conſtitution of it is not yet found out. That phlogiſton is contained in it, there can hardly be any doubt. That it alſo contains the matter of heat, appears from the ſenſible heat detached from it when deflagrated. But ſince inflammable air cannot penetrate through glaſs, as heat and light do, there muſt be ſome other element contained in it; unleſs it be ſuppoſed, that the difference in queſtion may have been produced by ſome difference in point of proportion, and mode of combination. By a long continued agitation in water, we are told, that it may be rendered fit for reſpiration.

CCCVIII.

The compoſition of the *hepatic air*, is a little better known to us: it conſiſts of ſulphur, which, by the help of phlogiſton, is united with the matter of heat. And, that theſe are its real conſtituent elements, may be demonſtrated, as well in the ſynthetic way, as in the analytic. It is remarkable, that ſulphur is, in this caſe, refined into an elaſtic inviſible fluid. It turns ſilver black.

CCCIX.

This ſort of air is obtained not only from hepar ſulphuris, by applying to it an acid, but alſo from ſulphur, when melted with iron filings, and from all *galenas*. Nature alſo generates it in many places in conſiderable quantities: for it is found in ſeveral mineral waters, ſuch as thoſe at Aix-la-Chapelle, &c.

CCCX.

The marine acid, owing to the ſmall attraction it has for phlogiſton, is the fitteſt to produce this air; on the other hand, nitrous acid, is, for the oppoſite reaſon, the unfitteſt: ſince it attracts the phlogiſton ſo ſtrongly, as not to let any of it eſcape, ſo as to ſerve for uniting the ſulphur with the matter of heat; it even deſtroys that union when already formed, and thereby affords a means of ſeparating the ſulphur from hepatic waters.

CCCXI.

Diſtilled water abſorbs a little more than half its bulk of hepatic air, and thereby contracts the ſame diſagreeable taſte and ſmell, as that elaſtic fluid itſelf poſſeſſes.

CCCXII.

This air extinguiſhes a burning candle when plunged into it; but, when $\frac{2}{3}$ of its bulk of common air is added to it, the mixture may be ſet on fire: in which caſe a ſulphureous powder precipitates from it, and a ſmell of phlogiſticated vitriolic acid may be perceived.

CCCXIII.

Means have alſo been found to bring ſeveral of the ſimple ſalts into the form of air: to wit, the vitriolic, the nitrous, the marine, that of ſpar, and the acetous acids, as alſo the volatile alkali; and to each of theſe we ſhall give a ſeparate conſideration.

CCCXIV.

The vitriolic acid may, even when pure, be brought by heat into the form of vapours; but theſe, upon cooling, loſe their elaſticity again, and run into a fluid as before. By this means, therefore, nothing is gained; upon adding, however, any ſubſtance which contains phlogiſton, the buſineſs is done very eaſily. The air thus obtained is called the *acid vitriolic air*.

CCCXV.

This elaſtic fluid muſt not be made to paſs through water: for if it be, it unites with it immediately, forming with it a phlogiſticated vitriolic acid: but if collected in veſſels filled with quickſilver, it retains its form, even in the greateſt degree of cold.

CCCXVI.

This fluid has a ſtrong attraction to water, and thence alſo ice diſſolves in it in a moment; and in the ſame manner it alſo converts camphire into a fluid oil.

CCCXVII.

When an electric ſpark is tranſmitted through this air, the inſide of the glaſs becomes covered every where with a black ſtain; which is the thicker, the oftener the experiment is repeated.

CCCXVIII.

Candles are extinguiſhed, and animals die in it.

CCCXIX.

This vitriolic air is nothing more than vitriolic acid, which is deprived of its redundant water, and is united, not only with phlogiſton, but with the matter of heat. Means, however, have not yet been found of charging it with phlogiſton in ſuch a manner, as to maſk its acid properties altogether. Theſe properties, however, are remarkably weak, and it accordingly gives place as well to the nitrous acid, as to the marine.

CCCXX.

The nitrous acid is remarkably greedy of phlogiſton, and accordingly forms with it, to the different proportions in which the two ingredients may be united, various compounds: among which we ſhall, in this place, ſpeak of thoſe only, which appear in the form of an elaſtic fluid, continuing ſuch in the cold.

CCCXXI.

When nitrous acid is applied to a body which contains phlogiſton, there ariſes from it, often without the help of the leaſt external heat, an elaſtic fluid, which may alſo be collected in water as well as quickſilver, and which is commonly called *Nitrous air.*

CCCXXII.

Water abſorbs a certain proportion of it, and alſo by degrees decompoſes a part of it, when they are kept ſtanding in contact with one another for a conſiderable length of time.

CCCXXIII.

The acid which enters into the compoſition of nitrous air is, in that caſe, ſo perfectly ſaturated with phlogiſton, that it cannot ſo much as give a colour to lacmus.

CCCXXIV.

Animals as well as vegetables, die in this air. A candle alſo is extinguiſhed in it: but, when it contains a redundant proportion of phlogiſton, over and above what is neceſſary for the ſaturation of the acid, the flame grows much larger, and becomes a little greeniſh, before the candle goes out. This ſuperſaturation may be produced, either by letting the air ſtand upon iron-filings, or by taking the electric ſpark in it.

CCCXXV.

This air reſiſts putrefaction, and that in a much greater degree than the aërial acid does.

CCCXXVI.

But the moſt remarkable circumſtance belonging to this air, is the appearance it exhibits with pure air [ſee 283] : the attraction of which for phlogiſton is ſo powerful, that it takes it away, in this caſe, even from nitrous air; which then becomes common nitrous acid as before. During the commixture of theſe two airs, a quantity of ſenſible heat is let looſe throughout the whole maſs, a reddiſh brown colour is produced, and the ſum of the ſpaces occupied by both becomes much ſmaller than it was before. A given meaſure of pure air can even abſorb three times its own bulk of nitrous air, before the ſpace it occupies can be ſeen to be much augmented.

CCCXXVII.

Common air, as it contains a portion of pure air, and by that means alone is enabled to ſupport combuſtion and reſpiration, exhibits accordingly, with nitrous air, a ſimilar appearance, although in a leſs degree [ſee 326]. Indeed, common air cannot, in general, abſorb more than half its bulk, without evidently occupying a larger ſpace than it did before.

CCCXXVIII.

In none of the kinds of air which are unfit for reſpiration, is either the red colour, or the diminution of ſpace, exhibited: conſequently, the nitrous air affords us an excellent means of judging of the purity of the [atmoſpheric] air. It is always the purer, the greater the change is which it exhibits, upon being mixed with nitrous air: and on this circumſtance is grounded the invention of the ſeveral ſorts of *Eudiometers* [ſee 51].

CCCXXIX.

When concentrated vitriolic acid is applied to common ſalt, a kind of air is detached, which, if collected by means of quickſilver, remains unaltered; but which is inſtantly abſorbed by water, to which it attaches itſelf in the form of common marine acid. This air is commonly called *Marine acid air*, and the marks it gives of its acidity are very evident.

CCCXXX.

Like the vitriolic acid, it diſſolves ice and camphire; flame is extinguiſhed by it, appearing blue at the inſtant of its evaneſcence.

CCCXXXI.

Electrical ſhocks tranſmitted through it diminiſh the bulk of it a little; but notwithſtanding this, the greateſt part of it is afterwards abſorbed by water.

CCCXXXII.

As neither the pure vitriolic acid nor the nitrous can be brought into the form of a permanent air, without the addition of phlogiſton, at the ſame time that the caſe is otherwiſe with the marine acid; this circumſtance inclines one to ſuppoſe, that phlogiſton may be an eſſential conſtituent part of it: a fact which is alſo indicated by other obſervations.

CCCXXXIII.

The marine acid may be deprived of its phlogiſton, as well by nitrous acid as by mangancſe. It ſhows itſelf in this ſtate in the form of a reddiſh brown air, without any acidity, and without any particular inclination to unite with water, &c. In this ſtate it is called dephlogiſticated marine acid. By the re-addition of phlogiſton,

giſton, it may be made to reaſſume all the properties of common marine acid.

CCCXXXIV.

From the ſparry fluor, by means of the vitriolic acid, may be expelled an air a good deal ſimilar to that which is obtained from the vitriolic acid itſelf; but this ſparry acid air has not yet been ſufficiently examined.

CCCXXXV.

Vinegar, when ſtrongly concentrated, yields, by mere boiling, an acid air, which muſt be collected by means of quickſilver, being immediately abſorbed by water: it is called *acetous air*.

CCCXXXVI.

Oil abſorbs it greedily, to the amount even of ten times its own bulk. The oil becomes thereby thinner as well as whiter, which is juſt the reverſe of the effect produced on it by the mineral acids; theſe giving it colour, and rendering it more tenacious than before.

CCCXXXVII.

The aërial acid bears a reſemblance, in ſeveral reſpects, to the airs obtained from the acids mentioned above [ſee from 314 to 336]; but, on the other hand, it is not ſo quickly abſorbed by water, and it precipitates the lime from lime-water; not to mention various other properties by which it differs from them. In the mean time, to judge from analogy, it ſeems very probable, that phlogiſton is one conſtituent part of it [ſee 332]. But, although this fact ſhould be put out of doubt by experiments, it would be no proof, but that this may be as much an air *ſui generis*, as any other. Phlogiſton may, in the moſt evident manner, be ſeparated from marine acid; and the fact of their union may be demonſtrated, as well by ſyntheſis as by analyſis, which is more than hath as yet ever been done with regard to the aërial acid. Notwithſtanding this, it never ſurely entered into the head of any one, to refuſe to the firſt-mentioned ſubſtance its peculiar place among the real acids.

CCCXXXVIII.

From cauſtic volatile alkali may alſo be obtained a kind of air by heat alone. This alkaline air muſt be collected by means of quickſilver; for it is abſorbed by water, and is then not to be diſtinguiſhed from a common alkaline ſolution.

CCCXXXIX.

When this air is applied to any of the acid kinds of air, the compound becomes viſible in the form of a cloud, which afterwards concretes into ſaline cryſtals, which are in the nature of ſo many ammoniacal ſalts, according to the ſpecies of the acid. Nitrous and inflammable airs give but ſmall ſigns of being affected by it; upon receiving it, however, with either of thoſe airs, ſomething like a precipitation may be ſeen.

CCCXL.

A candle is extinguiſhed in it; but at the moment of extinction the flame is enlarged, and becomes yellowiſh.

CCCXLI.

Ice melts in it very quickly, but oils do not abſorb it.

CCCXLII.

When electrical ſhocks are tranſmitted through it, the ſpace it occupies is increaſed by every ſhock. In this caſe, in proportion to the augmentation made in its bulk, its inflammability is encreaſed, and its diſpoſition to be abſorbed by water is diminiſhed.

CCCXLIII.

When all the ſeveral above-mentioned ſubſtances are thoroughly known, in regard to their compoſition, then, and not till then, will it be time to form juſt ideas reſpecting the elements themſelves; and to attempt to give an anſwer to the queſtion, whether all things are created out of one ſingle element, or out of two, or other ſmall and determinate number of elements? With reſpect to this, it may be worth while to obſerve, that becauſe ſuch or ſuch a method appears to us, when conſidering it with reference to our own power, the eaſieſt to purſue, we are not to conclude that this muſt neceſſarily be the method, of all others, that nature has actually purſued. Our buſineſs is, in the firſt place, to make ſure of underſtanding the nature of bodies as they are; and then it will be time enough to ſet about enquiring from whence they may have derived their origin.

With Newton, then let us learn to aſcend, by experiments and obſervations, from the phenomena to their real cauſes; and not, with Des Cartes, deſcend from fancied cauſes to the phenomena; which, in that caſe, muſt always be tampered with and diſtorted, in order to force them into a coincidence with the preconceived hypotheſis.

THE END.

ERRATA.

Page 18, Line 15, for *proportion*, read *propoſition.*
p. 40, l. 7 and 9, for *it*, read *they.*
p. 69, l. 10, for *opipeiary*, read *opificiary.*
p. 74, l. 15, for *experiment*, read *experience.*
p. 133, l. 21, for *phlogiſticated air*, read *foul air.*
p. 139, laſt line, read *conſiſts not.*
p. 152, l. 5, for *accordingly forms with it*, read *forms with it according, &c.*